1257

BOONTON

BOONTON ELECTRONICS CORPORATION

MODEL 4300
INSTRUCTION MANUAL

MP MASTER
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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation and maintenance of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instruments. Boonton Electronics assumes no liability for the customer's failure to comply with these requirements.

THE INSTRUMENT MUST BE GROUNDED.
To minimize shock hazard the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three conductor, three prong a.c. power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to a two-contact adapter with the (green) grounding wire firmly connected to an electrical ground at the power outlet.

DO NOT OPERATE THE INSTRUMENT IN AN EXPLOSIVE ATMOSPHERE.
Do not operate the instrument in the presence of flammable gases or fumes.

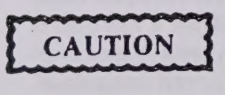
KEEP AWAY FROM LIVE CIRCUITS.
Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with the power cable connected. Under certain conditions dangerous voltages may exist even though the power cable was removed; therefore, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE.
Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

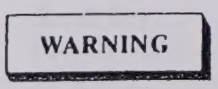
DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.
Do not install substitute parts or perform any unauthorized modification of the instrument. Return the instrument to Boonton Electronics for repair to ensure that the safety features are maintained.

SAFETY SYMBOLS.

This safety requirement symbol (located on the rear panel) has been adopted by the International Electrotechnical Commission, Document 66 (Central Office) 3, Paragraph 5.3, which directs that an instrument be so labeled if, for the correct use of the instrument, it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source. Verify that the correct fuse is installed for the power available, and that the switch on the rear panel is set to the applicable operating voltage.

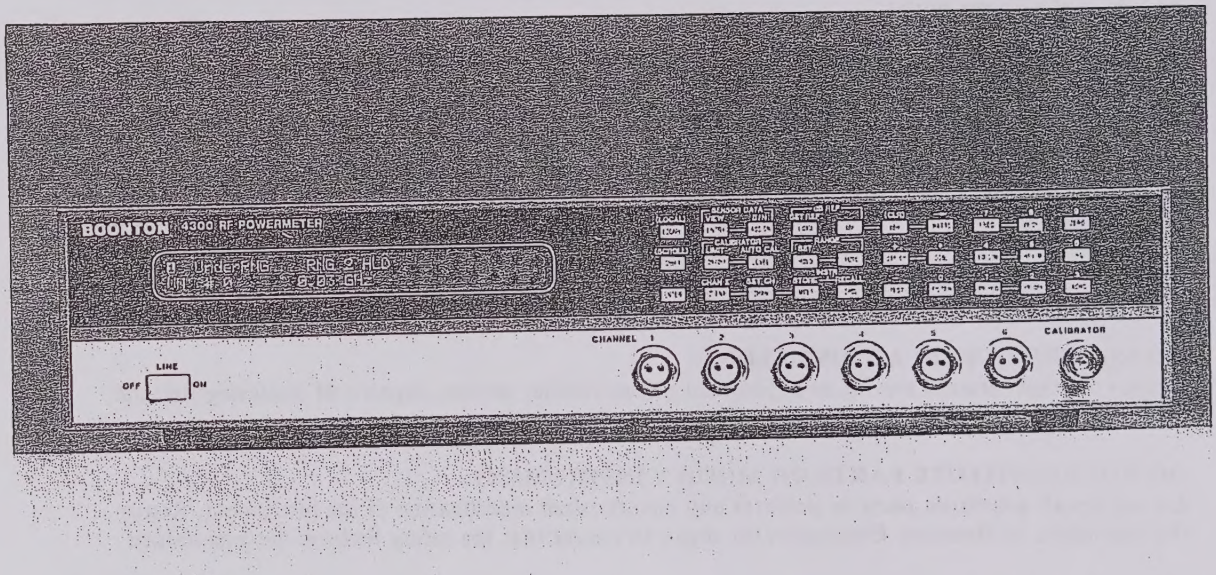


The CAUTION sign denotes a hazard. It calls attention to an operation procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the equipment. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.



The WARNING sign denotes a hazard. It calls attention to an operation procedure, practice, or the like, which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

Indicates dangerous voltages.



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SECTION 1
GENERAL INFORMATION

1-1. INTRODUCTION.

This instruction manual provides general information, installation and operating instructions, applications, theory of operation, maintenance instructions, parts list, and schematics for the Model 4300 RF Powermeter. Refer to Figures 1-1 and 1-2.

1-2. DESCRIPTION.

The Model 4300 is a microprocessor-based solid state RF powermeter. The instrument is capable of measuring 6 simultaneous RF power levels from 0.1 nW (-70 dBm) to 2W (+33 dBm) over a frequency range of 100 kHz to 110 GHz. The instrument's power and frequency ranges are determined by the sensors used with the instrument. The 4300 series sensors are fully compatible with the Model 4200.

The Model 4300 design features are as follows:

1. **Multiple real time measurements.** 6 simultaneous measurements can be performed, automatically ranged and processed with their own Z80 microprocessor. Each channel operates independently and has its own set of the following parameters: frequency, filter length, HI and LO limits, etc. A single 68008 microprocessor performs the final calibration, dB conversion, display, and bus operations. Measurement speed is typically 200 ms per 6 channel measurement over the bus. In single channel mode, there are typically 33 measurements per second. Each channel is autoranged independently, diode sensors have 7 ranges and thermal sensors have 4 ranges.

2. **Input Channel Modules.** The instrument can operate with one to six modules. Two Input Channel Modules are available. The 4311 Universal Channel Module is used with all the Boonton diode and thermal sensors. The 4312 Thermocouple Channel Module is used with Boonton thermal sensors only. The 4312 is optimized for thermocouple heads and is 5 dB lower in noise. The Input Channel Modules are field installable.

3. **Sensors.** The 4300 series sensors cover -60 dBm to +33 dBm (-70 dBm with long digital filtering and limited accuracy) and 100 kHz to 110 GHz.

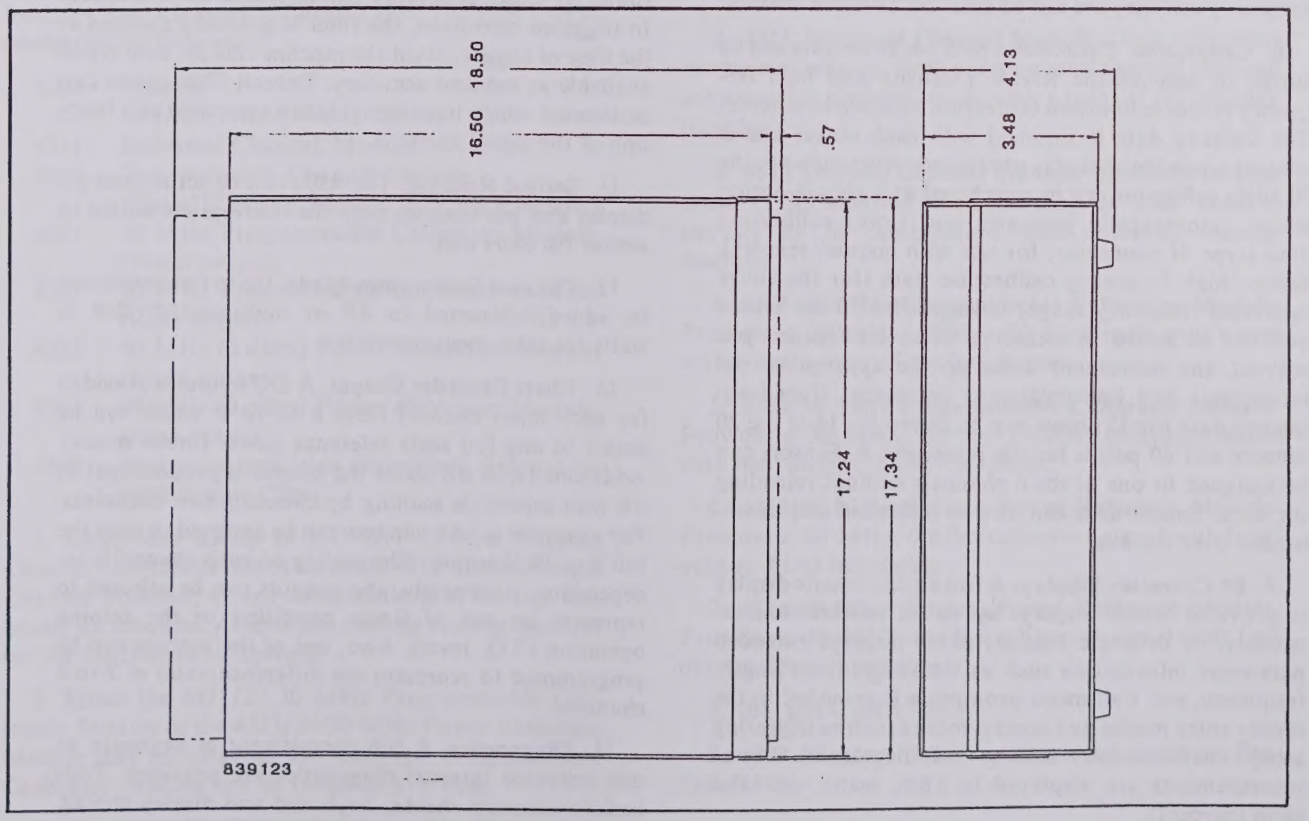


Figure 1-2. Outline Dimensions

4. **Diode Sensors.** Diode sensors measure the voltage across a precision resistor using specially selected diodes. The detection is square-law (true RMS) over the bottom two thirds of their range (roughly) and peak detecting at the top; however, the instrument is calibrated for sine-waves over the entire region. Therefore, measurements at the top are valid only for non-modulated signals. In the rms region the linearity error is extremely good and any signal type can be measured.
The diode response has been extended into the peak detecting region with the use of real time shaping for the diode curve, which when used with the 30 MHz programmable calibrator gives shaping errors less than .01 dB. When coupled with the high sensitivity of the diodes this method allows an unprecedented 80 dB or more of dynamic range per sensor. Diode sensors are rugged and have >5 dB or overload headroom on the top for continuous signals. The RMS region can be extended by using an external attenuator if desired.

5. **Thermal Sensors.** Thermal sensors measure the voltage developed across a dissimilar metal junction caused by the thermal gradient that the RF power generates. Since they are heat detecting they are true RMS responding over their entire range. They can also handle very high peak powers (15-30 watts) for very short duty cycles and still give valid results. The dynamic range is 40 dB (50 dB with long filtering and degraded accuracy) and they are not as sensitive as diode sensors.

6. **Calibration.** Calibration data for 20 sensors can be stored in non-volatile RAM. Linearity and high frequency sensor calibration correction data can be entered. The linearity data is supplied with each sensor and is entered when the sensor is purchased. Alternatively, the 30 MHz calibrator can be purchased as a plug-in option which automatically generates and stores calibration data (type N connector, for use with coaxial sensors). Sensor high frequency calibration data (for the entire operating frequency range) is supplied with the sensor and can be stored in memory. When the frequency is entered, the instrument looks up the appropriate cal factor data and interpolates as necessary. High frequency data for 35 points can be stored for 14 of the 20 sensors and 80 points for the remaining 6. Sensors can be assigned to one of the 6 channels without reloading the data. Sensor data can also be uploaded and downloaded over the bus.

7. **80 Character Display.** A full alphanumeric display is provided which displays up to six powers simultaneously, or in single channel mode displays extended parameter information such as the range, filter length, frequency, etc. Full menu prompting is provided in the sensor entry modes and special modes such as triggering setup, chart recorder scaling and diagnostics. Power measurements are displayed in dBm, watts, dBr and ratio (percent).

8. **Traceable 30 MHz Calibrator.** The 4321 30 MHz Programmable Calibrator Module provides a 30 MHz signal at a level from -60 dBm to +20 dBm in 1 dB steps. The basic accuracy is 0.05 dB. Each unit is calibrated with references back to the 30 MHz piston attenuator, an NBS traceable attenuation standard, which is accurate to .003 dB/10 dB. (NBS does not certify attenuation at 50 MHz.) This gives the user a high confidence factor at power levels other than 0 dBm. Alternate techniques use either a 1 MHz attenuation standard or assumed linearity. When connected to a sensor, the 4321 will automatically generate the linearity/attenuation correction constants for coaxial sensors. This function is executed from the front panel. The unit can be installed with a front or rear panel output.

9. **50 MHz Calibrator.** The 4323 Power Reference Module provides a 50 MHz (0 dBm) signal for applications requiring 50 MHz traceability at 0 dBm. The 4323 is used when the increased accuracy of 4321 30 MHz Programmable Calibrator Module is not necessary. The unit can be installed with a front or rear panel output and may also be installed concurrently with the 4321, (one front and one rear).

10. **Selectable Filtering.** The 4300 provides a digital pipeline filter (moving average, equal weighting) from 1 to 1000 samples (20 msec to 20 sec) so that noise, either source or sensor generated, can be traded off with speed. In triggered operation, the filter is generally dumped at the time of trigger. Until the pipeline fills up, data is still available at reduced accuracy. Default filter values can be selected which have been chosen optimally as a function of the signal level.

11. **Settled Reading.** The 4300 can be set to hold off display and bus updates until the readings are settled to within 1% (0.04 dB).

12. **Channel Summation Mode.** Up to 6 channels can be added/subtracted in dB or multiplied/divided in watts for ratio measurements.

13. **Chart Recorder Output.** A DC output is provided for each input channel from 0 to 10 V which can be scaled to any full scale reference power (linear mode). Additionally, in dB mode the output is proportional to dB with selectable scalling by choosing two endpoints. For example: a 1 dB window can be assigned to span the full 0 to 10 V output. The scaling on each channel is independent. Alternately, the outputs can be selected to represent an out of limits condition or the zeroing operation (TTL level). Also, one of the outputs can be programmed to represent the difference/ratio of 2 to 6 channels.

14. **Diagnostics.** A full complement of keyboard or bus activated internal diagnostics are provided. Tests include memory checks, keyboard and display checks,

and when the 30 MHz calibrator is installed, a complete measurement chain check.

15. **GPIB.** (Standard)

16. **MATE.** MATE operation is provided if the option is selected.

17. **Zeroing.** Automatic zeroing (nulling of offsets from the sensor and input channels) is done independently on each range to eliminate zero carryovers. Zeroing time is from 8 to 20 seconds depending on the digital filter selected.

18. **Setup Registers.** Nine panel setup states can be stored in the non-volatile memory. In addition, learn strings can be downloaded from the bus to set up the instrument and load sensor data.

19. **Pulse Power.** Although the instrument is an average power meter, for rectangular waveforms the duty cycle can be entered and the instrument will calculate the pulse (peak) power. This is valid in the RMS regions of the diode sensors and over the full operating range of the thermal sensors. For the diode sensors, the RMS region is extended slightly with the use of internal correction curves.

1-3. CONFIGURATION.

The Model 4300 RF Power Meter is a chassis that contains six module slots for installation of the 4300 input modules, and a seventh calibrator slot. The 4300 may be configured as follows:

4300	Chassis.
-06	Internal TMA (Mate) Option.
4311	Universal Channel Module.
4312	Thermocouple Channel Module. (The 4312 cannot be used with diode sensors).
4321	30 MHz Programmable Calibrator Module, (Front output).
4322	30 MHz Programmable Calibrator Module, (Rear output).
4323	50 MHz (0 dBm) Power Reference Module, (Front output).
4324	50 MHz (0 dBm) Power Reference Module, (Rear output).
4300	Sensors. Application dependent. Refer to the 4300 Sensor Chart.

1. Either one or up to six 4311 General Purpose Channel Modules or one or up to six 4312 Thermocouple Channel Modules, or any combinations of the two that equals six modules. At least one module must be installed for the instrument to operate.

2. Either the 4321/22 30 MHz Programmable Calibrator Module or the 4323/24 50 MHz Power Reference Module may be installed; but, only one Programmable Calibrator Module can be installed at a time.

3. Two 50 MHz Power Reference Modules can be installed, one 4323 (front output) and one 4324 (rear output).

1-4. ACCESSORIES.

The following accessories are supplied with the instrument:

1. **AC power cord.**

2. **Fuse kit** for 220/240 VAC.

The following sensors are listed in Table 1-1.

The following accessories are available:

1. **41-2A/10 Sensor/Probe Interconnecting Cable.** (10 ft.)(m/m). A special low noise cable that connects the power sensor to the power meter.

2. **41-2A/20 Sensor/Probe Interconnecting Cable.** (20 ft.).

3. **41-2A/50 Sensor/Probe Interconnecting Cable.** (50 ft.).

4. **41-2A/100 Sensor/Probe Interconnecting Cable.** (100 ft.).

5. **950043 Chassis slide rack mounting kit.**

1-5. OPTIONS.

The following options are available for the instrument:

1. **Rack mount hardware kits.**

2. **4311 Universal Channel Module.** Used with diode or thermal sensors. Both universal and thermal channels may operate simultaneously with a total of six channels installed.

3. **4312 Thermal Channel Module.** Used with thermal sensors. Six thermal channels may be used simultaneously or in combination with universal channel modules.

4. **4321 30 MHz Programmable Calibrator Module.** Provides a 30 MHz, -60 to +20 dBm calibrator signal with front output. Field installable.

5. **4322 30 MHz Programmable Calibrator Module.** Provides a 30 MHz, -60 to +20 dBm calibrator signal with rear output. Field installable.

6. **4323 50 MHz (0 dBm) Power Reference Module.** Provides a 50 MHz, 0 dBm calibrator signal with front output. Field installable.

7. **4324 50 MHz (0 dBm) Power Reference Module.** Provides a 50 MHz, 0 dBm calibrator signal with rear output. Field installable.

8. **-06 TMA (MATE).**

9. **4300 Sensors.** Refer to the sensor Table in Section 1-4.

1-6. SPECIFICATIONS.

Performance specifications are listed in Table 1-2.

TABLE 1-1. SENSOR CHARACTERISTICS

Model (Impedance) (RF Connector)	Freq Range	PWR Range (Watts) (dBm)****	Overload Rating (Watts) (dBm)	Max. SWR Frequency	Max. SWR SWR	Drift and Noise Lowest Range Auto Filter, 4300 Drift (typical) 1 Hr***	Noise (typical) RMS	Noise (typical) 2 σ
DIODE SENSORS								
51011 (4B) 50Ω N(M)	100 kHz to 12 4 GHz	0 1 nW to 100 mW -70 to +20 dBm	300 mW +25 dBm	100 kHz to 2 GHz 2 GHz to 4 GHz 4 GHz to 11 GHz 11 GHz to 12.4 GHz	1 12 1 2 1.4 1.6	150 pW	65 pW	130 pW
51012 (4C) 75Ω N(M)	100 kHz to 1 GHz	0 1 nW to 100 mW -70 to +20 dBm	300 mW +25 dBm	100 kHz to 1 GHz	1 18	150 pW	65 pW	130 pW
51013 (4E) 50Ω N(M)	100 kHz to 18 GHz	0 1 nW to 100 mW -70 to +20 dBm	300 mW +25 dBm	100 kHz to 4 GHz 4 GHz to 10 GHz 10 GHz to 18 GHz	1 3 1.5 1.7	150 pW	65 pW	130 pW
51051 (4G) 50Ω APC 3.5 (M)	1 MHz to 26 5 GHz	0 1 nW to 10 mW -70 to +10 dBm	300 mW +25 dBm	1 MHz to 12.4 GHz 12.8 GHz to 18 GHz 18 GHz to 26.5 GHz	1 28 1.37 1.92	100 pW	30 pW	60 pW
51015 (5E) 50Ω N(M)	100 kHz to 18 GHz	1 0 nW to 1 W -60 to +30 dBm	2W +33 dBm	100 kHz to 1 GHz 1 GHz to 2 GHz 2 GHz to 4 GHz 4 GHz to 12.4 GHz 12.4 GHz to 18 GHz	1.07 1.10 1.12 1 18 1.28	1.5 nW	.65 nW	1.3 nW
51033 (6E) 50Ω N(M)	100 kHz to 18 GHz	10 nW to 2 W -50 to +33 dBm	2 W +33 dBm	100 kHz to 1 GHz 1 GHz to 2 GHz 2 GHz to 4 GHz 4 GHz to 12.4 GHz 12.4 GHz to 18 GHz	1.07 1.10 1 12 1 18 1 28	15 nW	6.5 nW	13 nW
THERMOCOUPLE SENSORS (with 4312 input module)**								
51016 (7E) 50Ω N(M)	10 MHz to 18 GHz	100 nW to 10 mW -40 to +10 dBm	30 mW +15 dBm*	10 MHz to 15 MHz 15 MHz to 10 GHz 10 GHz to 18 GHz	1 5 1.35 1 6	150 nW	65 nW	130 nW
*Thermocouple Pulse Characteristics at 25°C: Maximum pulse energy = 5 W-μsec Maximum pulse power = 1 W. Maximum pulse duration at maximum pulse power = 5 μsec.								
51017 (8E) 50Ω N(M)	10 MHz to 18 GHz	1.0 μW to 100 mW -30 to +20 dBm	200 mW +23 dBm*	10 MHz to 15 MHz 15 MHz to 10 GHz 10 GHz to 18 GHz	1 5 1 35 1 6	1.5 μW	650 nW	1 3 μW
*Thermocouple Pulse Characteristics at 25°C: Maximum pulse energy = 30 W-μsec Maximum pulse power = 15 W. Maximum pulse duration at maximum pulse power = 2 μsec								
WAVEGUIDE SENSORS								
51035 (4K) WR-42 UG-595/U	18 GHz to 26 5 GHz	1 0 nW to 10 mW -50 to +10 dBm	100 mW +20 dBm	18 GHz to 26.5 GHz	1 3	200 pW	60 pW	120 pW
51036 (4KA) WR-28 UG-599/U	26.5 GHz to 40 GHz	1 0 nW to 10 mW -50 to +10 dBm	100 mW +20 dBm	26 5 GHz to 40 GHz	1 3	60 pW	15 pW	30 pW
51037 (4Q) WR-22 UG-383/U	33 GHZ to 50 GHz	1.0 nW to 10 mW -50 to +10 dBm	100 mW +20 dBm	33 GHz to 50 GHz	1 3	60 pW	15 pW	30 pW
51045 (4U) WR-19 UG-383/U	40 GHz to 60 GHz	1 0 nW to 10 mW -50 to +10 dBm	100 mW +20 dBm	40 GHz to 60 GHz	1 3	60 pW	15 pW	30 pW
51046 (4V) WR-15 UG-385/U	50 GHz to 75 GHz	1.0 nW to 10 mW -50 to +10 dBm	100 mW +20 dBm	50 GHz to 75 GHz	1 3	60 pW	15 pW	30 pW
51047 (4W) WR-10 UG-387/U	75 GHz to 110 GHz	3 2 nW to 10 mW -45 to +10 dBm	100 mW +20 dBm	75 GHz to 110 GHz	1 3	60 pW	15 pW	30 pW
51972-WRD WRD180C24	18 GHz to 40 GHz	1 0 nW to 10 mW -50 to +10 dBm	100 mW +20 dBm	18 GHz to 40 GHz	1 3	200 pW	60 pW	120 pW

NOTES: *Will withstand short periods of overload, extended overload operation may result in permanent change in characteristics or burnout.
**For the 4311 input module, multiply noise and drift by 3.2, and decrease the dynamic range on the bottom end by 5 dB
***After 2 hour warmup.
****The power range on the bottom end is limited by noise, which may be higher than the specified limit unless long digital filtering is used Refer to Section 4 regarding accuracy at low levels

Power linearity uncertainty: (worst case) 4B, 4C, 4E: (.005 x f) dB per dB above +4 dBm; (above +14 dBm for the 5E and above +24 dBm for the 6E), where f is in GHz.

TABLE 1-2. SPECIFICATIONS

Frequency Range:	100 kHz to 110 GHz, sensor dependent.
Power Range:	-70 dBm to +33 dBm, sensor dependent. -70 dBm with reduced accuracy.
Power Sensors:	Compatible with all Boonton diode and thermal sensors. See Sensor Characteristics
Dynamic Range:	70 to 90 dB with diode sensors. (See Sensor Characteristics.) 50 dB with thermocouple sensors.
Inputs:	Front and Rear panel inputs, standard for each channel module installed Each channel is an independent measuring unit. One to six channels. IEEE-Bus connector.
Rear Panel Outputs:	Type BNC connector(s) one for each channel module installed; the output is front panel/IEEE Bus selectable for linear or logarithmic output proportional to function selected (0 to 10V). Can also be selected for high/low limit status and zero status.
Measurement Modes:	Single Channel; Summation Channel (Ratio); and Multiple Channel, (all channels displayed simultaneously).
Display Units:	Absolute; Watts, dBm. Ratio (summation); dB or % (Channel 1 ± Channel 2 ± Channel 3 ± Channel n) Relative; dBr
Resolution:	Watts, in nW, μW, mW, W, (4½ digits) dBm dB, .01 dB.
Display:	Alphanumeric backlit LCD, 2 lines of 40 characters each.

Instrument:

Uncertainty(1)	**RSS**	**Worst Case**
Single Channel Mode (2)	0.12% (0.005 dB)	0.3% (0.013 dB)
Zeroing	.01% (.0005 dB)	.025% of F.S.
Shaping (3)	0.015% (0.0007 dB)	0.12% (.005 dB)
Total uncertainty	0.14% (0.006 dB)	0.42% + .025% of F.S. (0.67% Max.)

(1) Total measurement uncertainty is the sum of Instrument uncertainty, Power Reference/Calibrator uncertainty, Noise and Calibration Factor uncertainty and Power Linearity uncertainty. The most probable uncertainty is the RSS of these uncertainties. See Table 1-3 for Calibration Factor uncertainty. See Table 1-1 for Sensor Noise and Power Linearity Uncertainty.
(2) Accuracy in Summation (Ratio) mode is n x single channel where n = number of channels.
(3) Add 1% (.04 dB) when using 50 MHz Power Reference or Waveguide sensors

Power Reference/Calibrator	
50 MHz (0 dBM) Power Reference:	Internal 50 MHz source with type N female connector. Set to 0.7% (.03 dB) at 0 dBm. Front or rear panel. (18-28°C). VSWR 1.01. The worst case uncertainty for one year is 1.2%. (0-55°C.), RSS 0.9% (.04 dB).
30 MHz Programmable Calibrator:	Internal 30 MHz source with programmable level between -60 dBm and +20 dBm, 1 dB steps. Front or rear panel. (20-30°C). At 0-20° and 30-50°C add 0.35% (.015 dB).

TABLE 1-2. SPECIFICATIONS (Cont.)

30 MHz Programmable Calibrator Uncertainty:

Level	RSS	Worst Case
@ 0 dBm	0.6% (.025 dB)	0.9% (.04 dB)
+20 dBm to -39 dBm	0.7% (.03 dB)	1.4% (.06 dB)
-40 dBm to -60 dBm	0.9% (.04 dB)	2.1% (.09 dB)

VSWR 1.05

Calibration Factors: +3 dB to -3 dB in .01 dB steps. These stored calibration factors are in non-volatile memory. When a frequency other than that stored is used, the 4300 linearly interpolates between the cal factor above and below the frequency entered to obtain a cal factor. Cal factors for up to 20 sensors can be stored with up to 80 frequencies for sensors 1-6 and 35 frequencies for sensors 7-20.

Ranging: Autoranging, set-ranging and hold on range; each channel operating independently. 10% headroom. Hold on range: 25 dB dynamic range on each range; 0.2 dB resolution at -25 dB point.

Settling Time: 0-99%, 10 dB power step, hold range, filter set to 20 ms. Readout over the IEEE Bus:

Diode sensors: <200 ms
Thermocouple sensors: <450 ms

Output Data Speed: Free run access time is typically 30 msec per channel or 33 readings per second.

Filtering. Filtering is selected by entering the filter time in ms, between 20 ms and 20 s. Filtering is accomplished in 20 ms increments, e.g., selecting 2000 ms selects 100 point averaging.

Auto filtering selects the following default values:

Range	Diode Channel filter time	Thermal Channel filter time
0	2.8 sec	4.8 sec
1	0.8	1.8 sec
2	0.3	0.6
3	0.06	0.3
4	0.06	---
5	0.06	---
6	0.06	---

Measurement time is the sum of settling time and filter time.

Zeroing: Each range is independently zeroed upon selecting the "ZERO" function either via front panel or over the bus.

Limits: Front panel or bus selectable between 99.9 and -99.9 dBm, independently for each channel.

Power Consumption: 40 VA; 100, 120, 220, 240V ±10%, 50 - 400 Hz.

Operating Temperature: 0-55°C. (High temperature display required above 50°C; consult factory.)

Weight: 21 lbs (9.5 kG) With 6 channels and programmable calibrator.

Dimensions: 3.48 in (8.8 cm) high, 17.24 in (43.8 cm) wide, and 17.75 in (45.0 cm) deep.

Environmental Characteristics: Meets MIL-T-28800C for Type II, Class 5, Style E and F equipment.

IEEE-488 Bus: Complies with IEEE-488 and implements: SH1, AH1, T6, L4, SR1, RL1, DC1, and DT1.

TABLE 1-3. SENSOR CALIBRATION FACTOR UNCERTAINTY

Sensor Calibration Factor Uncertainty

Sensor	Frequency GHz																		
	.03-.05*	<2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19-26.5
4B(51911)																				
Max. %	0	1.3	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.5	4.5							
RSS %	0	1.3	1.7	1.7	1.7	1.8	1.9	2.0	2.1	2.5	2.5	2.4	3.0							
4C(51012)																				
Max. %	0	1.3																		
RSS %	0	1.3																		
4E(51013)																				
Max. %	0	1.3	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.5	4.5	6.0	6.0	6.0	6.0	6.0	6.0	
RSS %	0	1.3	1.8	1.8	1.8	1.9	2.0	2.0	2.2	2.6	2.5	2.7	3.0	3.4	3.1	3.2	3.3	3.1	3.4	
4G(51051)																				
Max. %	0	1.3	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0
RSS %	0	1.3	1.7	1.7	1.7	1.7	1.8	1.9	2.0	2.4	2.3	2.2	2.6	3.0	2.8	2.8	2.9	2.8	3.1	3.4
5E(51015)																				
Max. %	0	1.3	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.5	6.0	6.0	6.0	6.0	6.0	6.0	
RSS %	0	1.3	1.7	1.7	1.7	1.7	1.8	1.9	2.0	2.4	2.3	2.2	2.8	3.0	2.8	2.8	2.9	2.8	3.1	
6E(51033)																				
Max. %	0	1.3	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.5	6.0	6.0	6.0	6.0	6.0	6.0	
RSS %	0	1.3	1.7	1.7	1.7	1.7	1.8	1.9	2.0	2.4	2.3	2.2	2.8	3.0	2.8	2.8	2.9	2.8	3.1	
7E(51016)																				
Max. %	0	1.3	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.5	6.0	6.0	6.0	6.0	6.0	6.0	
RSS %	0	1.3	1.8	1.8	1.8	1.8	1.9	2.0	2.1	2.5	2.4	2.6	2.9	3.3	3.1	3.1	3.2	3.0	3.4	
8E(51017)																				
Max. %	0	1.3	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.5	6.0	6.0	6.0	6.0	6.0	6.0	
RSS %	0	1.3	1.8	1.8	1.8	1.8	1.9	2.0	2.1	2.5	2.4	2.6	2.9	3.3	3.1	3.1	3.2	3.0	3.4	

*Reference Frequency = 30 or 50 MHz. Note: CAL Factors are supplied at every 1 GHz.

Wave Guide Sensor Calibration Factor Uncertainty

Sensor	Ref. GHz	At Ref. Freq.	Over Sensor BW	Sensor	Ref. GHz	At Ref. Freq.	Over Sensor BW	Sensor	Ref. GHz	At Ref. Freq.	Over Sensor BW	Sensor	Ref. GHz	At Ref. Freq.	Over Sensor BW
4K(51035)	22			4Q(51037)	40			4V(51046)	60						
Max. %		6	6	Max. %		10	13	Max %		12	13	WRD-180 (51972)	33		
RSS %		5	5	RSS %		6	7	RSS %		6	6				
4KA(51036)	33			4U(51045)	40			4W(51047)	94			Max. %		6	10
Max. %		6	10	Max. %		10	13	Max. %		12	13	RSS %		5	7
RSS %		5	7	RSS %		6	8	RSS %		9	11				

Note: For waveguide sensors, the reference calibration is at -20 dBm. For levels other than -20 dBm, add 01 dB/dB relative to - 20 dBm.

SECTION 2
INSTALLATION

2-1. INTRODUCTION.

This section contains instructions for the installation of the Model 4300 RF Powermeter, and for installation of the Input channels and the calibrators.

2-2. UNPACKING.

The Model 4300 is shipped complete and is ready to use upon receipt. Unpack the instrument from its shipping container and inspect it for damage that may have occurred during shipment. See Figure 2-1.

NOTE

Save the packing material and container for possible use in reshipment of the instrument.

2-3. MOUNTING.

For bench mounting, choose a clean, sturdy, uncluttered mounting surface. For rack mounting, an accessory kit is provided with the instrument that provides mounting ears and rear supports. The rack mounting kit contains the required hardware and instructions.

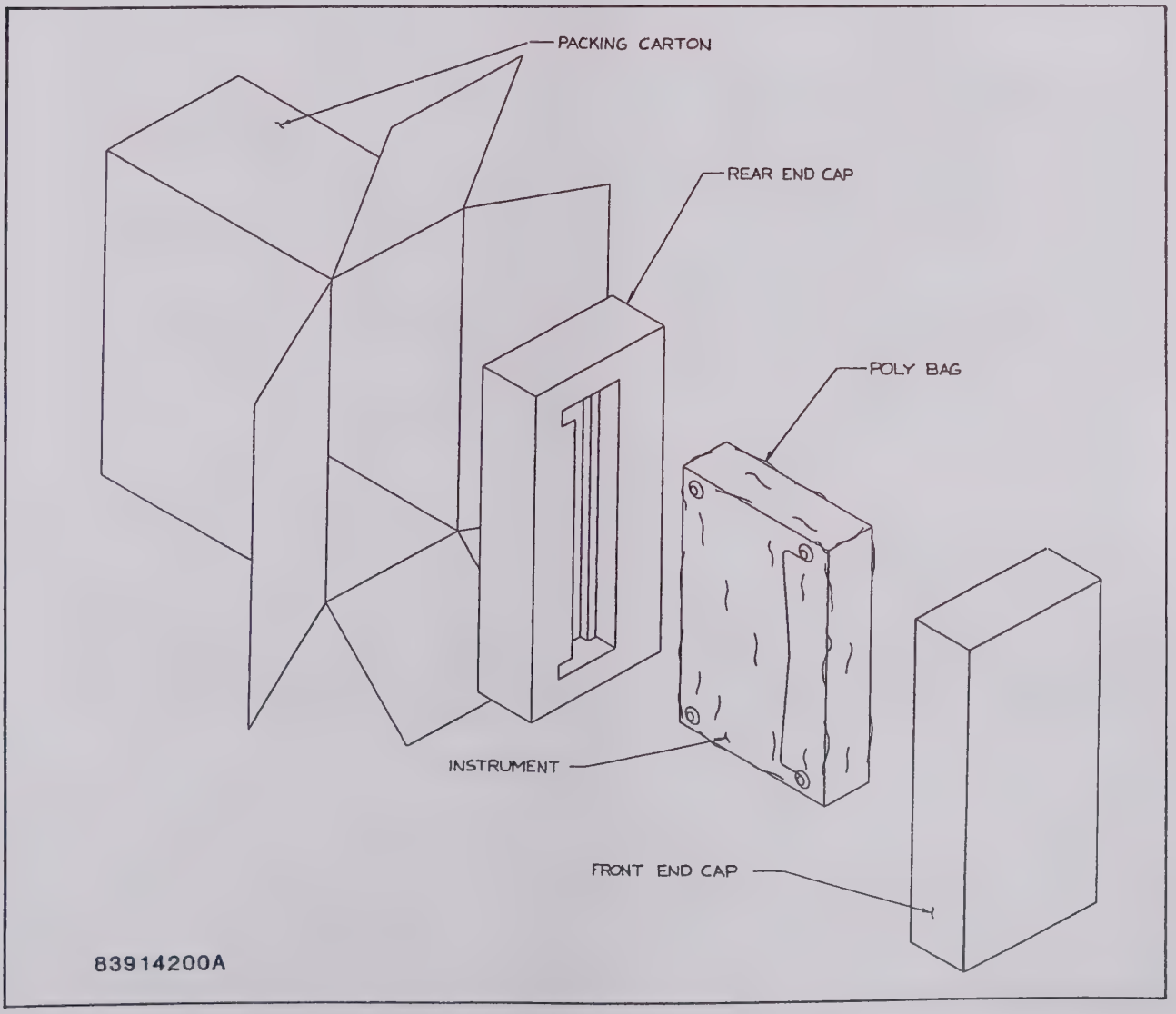


Figure 2-1. Packing and Unpacking Diagram

2-4. CALIBRATOR AND INPUT CHANNEL INSTALLATION

For installation instructions of the 30 MHz and 50 MHz calibrator options, and the input channels, refer to Figures 2-2, 2-3, 2-4, and 2-5. Early units require the keyboard to be removed to remove/install the calibrators when installed from the front.

2-5. POWER REQUIREMENTS.

The Model 4300 has a tapped power transformer and two line voltage selection switches which permit operation from 100, 120, 220 and 240 volt ± 10%, 50 to 60 Hz,* single phase AC power sources. Power consumption is approximately 40 VA.

*NOTE

Consult the factory for operation at 400 Hz.

CAUTION

Always make certain that the line voltage selector switches are set to the correct positions most nearly corresponding to the voltage of the available AC power source, and that a fuse of the correct rating is installed in the fuse holder before connecting the Model 4300 to any AC power source.

Set the line voltage selector switches, located on the rear panel to the appropriate positions as indicated on the LINE VOLTAGE SELECT chart located next to the switches. Check that the line fuse is correct for the selected power source. The correct fuse is:

VOLTAGE	FUSE
100/120 V	3/4 ATD
220/240 V	3/8 ATD

2-6. BATTERY POWER SUPPLY.

The 4300 employs a battery as backup power for the non-volatile memory on the control and the channel board assemblies. The battery is used to retain calibration data and setup information during times when AC power is not present. A primary lithium battery with a shelf life of 10 years is used.

2-7. CABLE CONNECTIONS.

Cable connections required depend on the use of the instrument. Refer to Section 3, OPERATION, for descriptions of the connections.

2-8. PRELIMINARY CHECKOUT.

The preliminary checkout ensures that the 4300 is functional to a fair degree of confidence. For a full performance checkout, refer to "Performance Verification" in the Maintenance section.

WARNING

The instrument must first be set to the proper line voltage. Refer to Section 2-5, or use the rear panel markings as a guide.

The procedure for checkout is as follows:

1. Connect the instrument to the AC line and power up.

2. Press SHIFT, RECALL, 0, ENTER. This initializes the instrument.

3. Press TEST, 1, ENTER. The display should indicate a number from 1 to 30 when any key (except ESCAPE) is pressed. Press ESCAPE.

4. Press TEST, 2, ENTER. In a few seconds the display should indicate blocks, then the entire alphabet. Press ESCAPE.

5. Press TEST, 3, ENTER. The display should indicate MEMORY OK.

6. Press TEST 7, ENTER. The display should indicate BATTERY TEST OK.

7. If the 30 MHz calibrator is installed, press LEVEL, 0, ENTER.

8. Connect a general purpose power meter to the 30 MHz or 50 MHz calibrator if installed and verify its level to be 0 +/- 0.2 dBm.

For verification of the input channels and sensors, sensor assignments must be verified first, and it must be ascertained that the sensor "14 point linearity data" has been entered for each of the sensors. Refer to the operating section for those procedures.

INSTALLING INPUT ASSEMBLY

1. REMOVE THE SCREWS THAT SECURE THE TOP AND BOTTOM COVERS. REMOVE COVERS.
2. SELECT ANY AVAILABLE POSITION TO INSTALL INPUT ASSY. (INSTALLERS PREFERENCE)
3. REMOVE ASSOCIATED HOLE PLUGS FROM REAR PANEL. DISCARD.
4. INSTALL INPUT ASSY AND SECURE IN PLACE WITH THREE SCREWS SUPPLIED. CONNECT P8 (PIN ON RED WIRE) INTO RED SOCKET ON SUB-PANEL AND CONNECT P7 (PIN ON BLACK WIRE) INTO WHITE SOCKET ON SUB PANEL.
5. INSTALL TOP AND BOTTOM COVERS
6. REMOVE CAP FROM ASSOCIATED INPUT CONNECTOR ON FRONT OF UNIT. DISCARD.

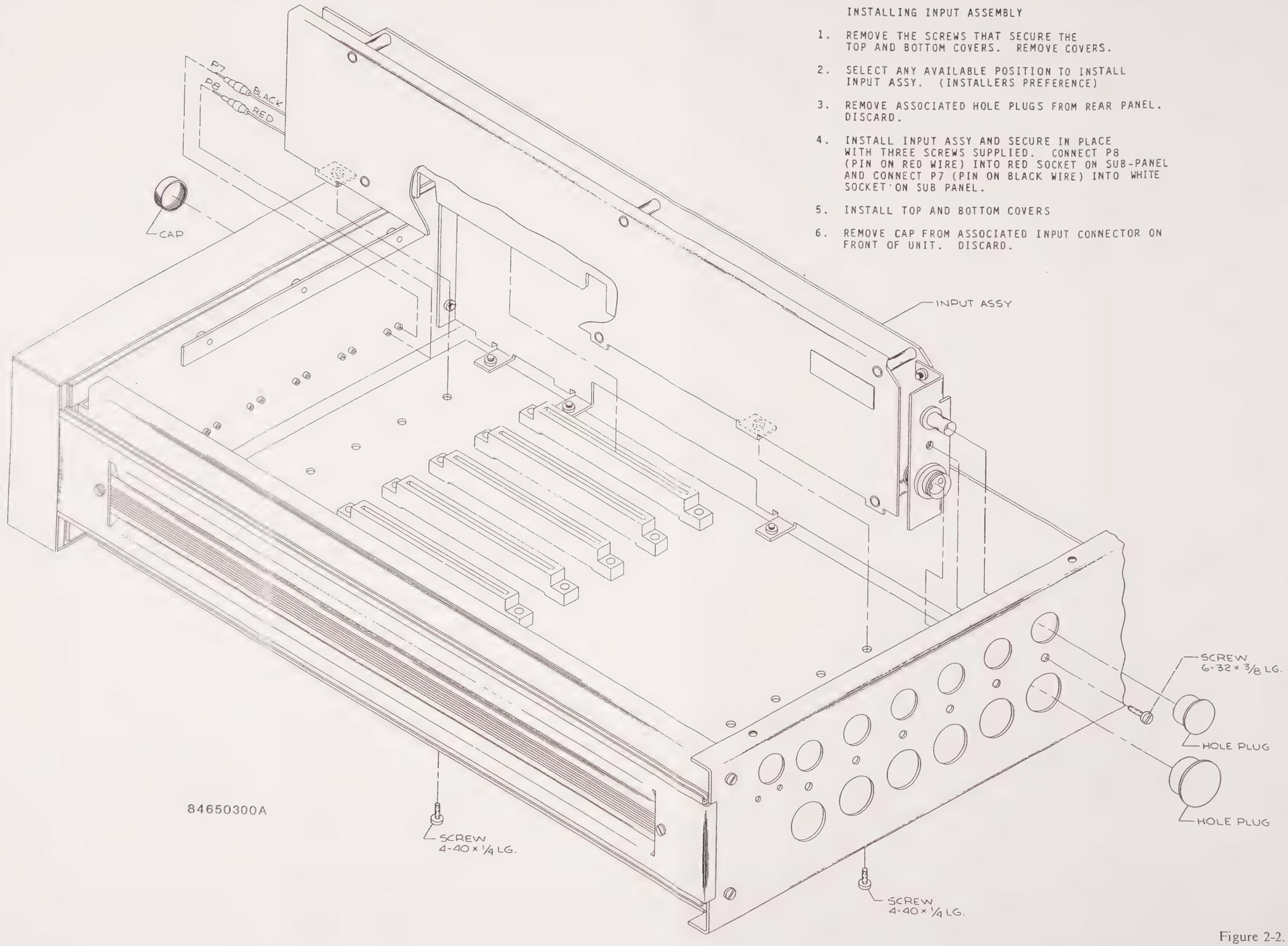
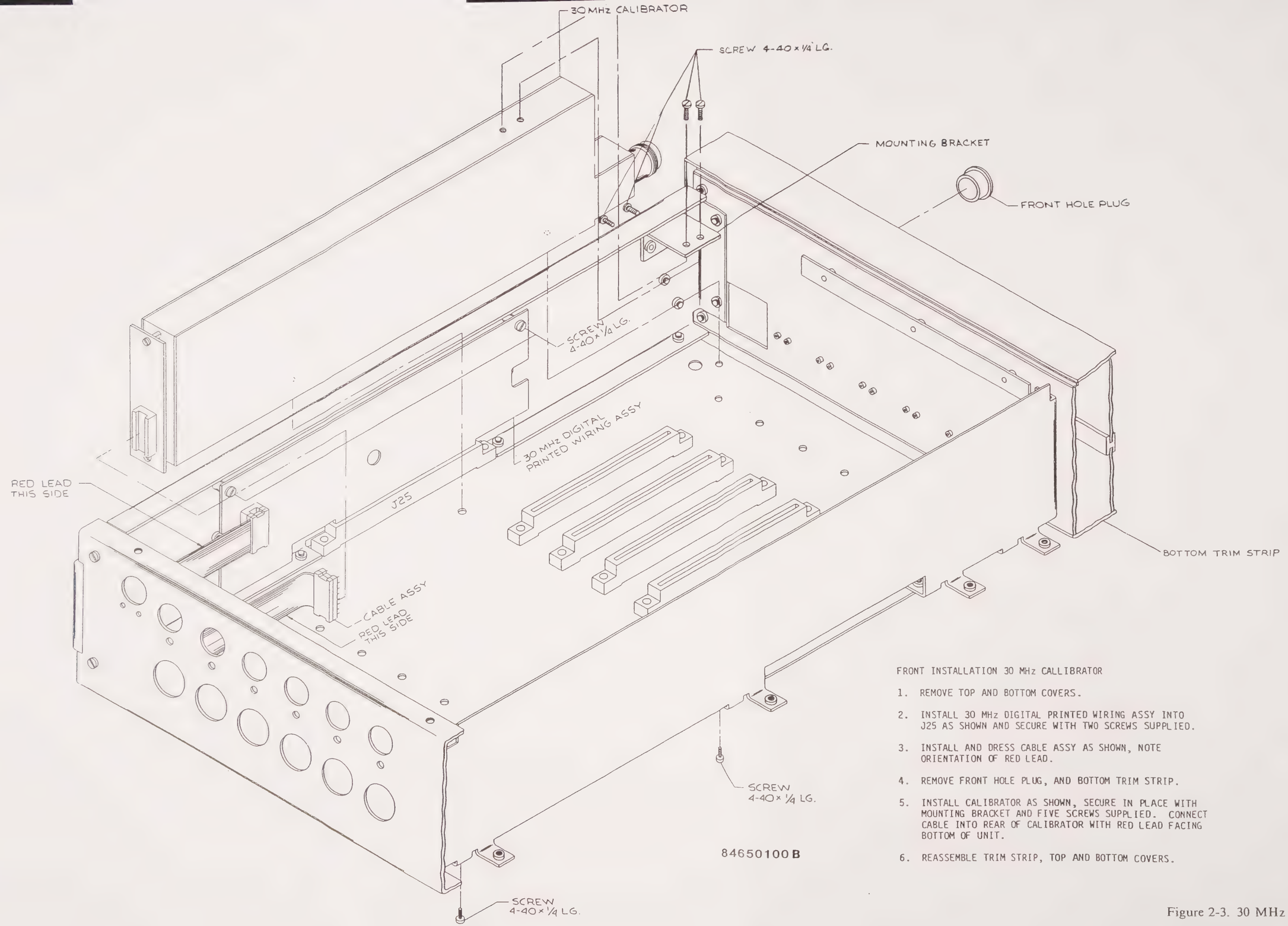


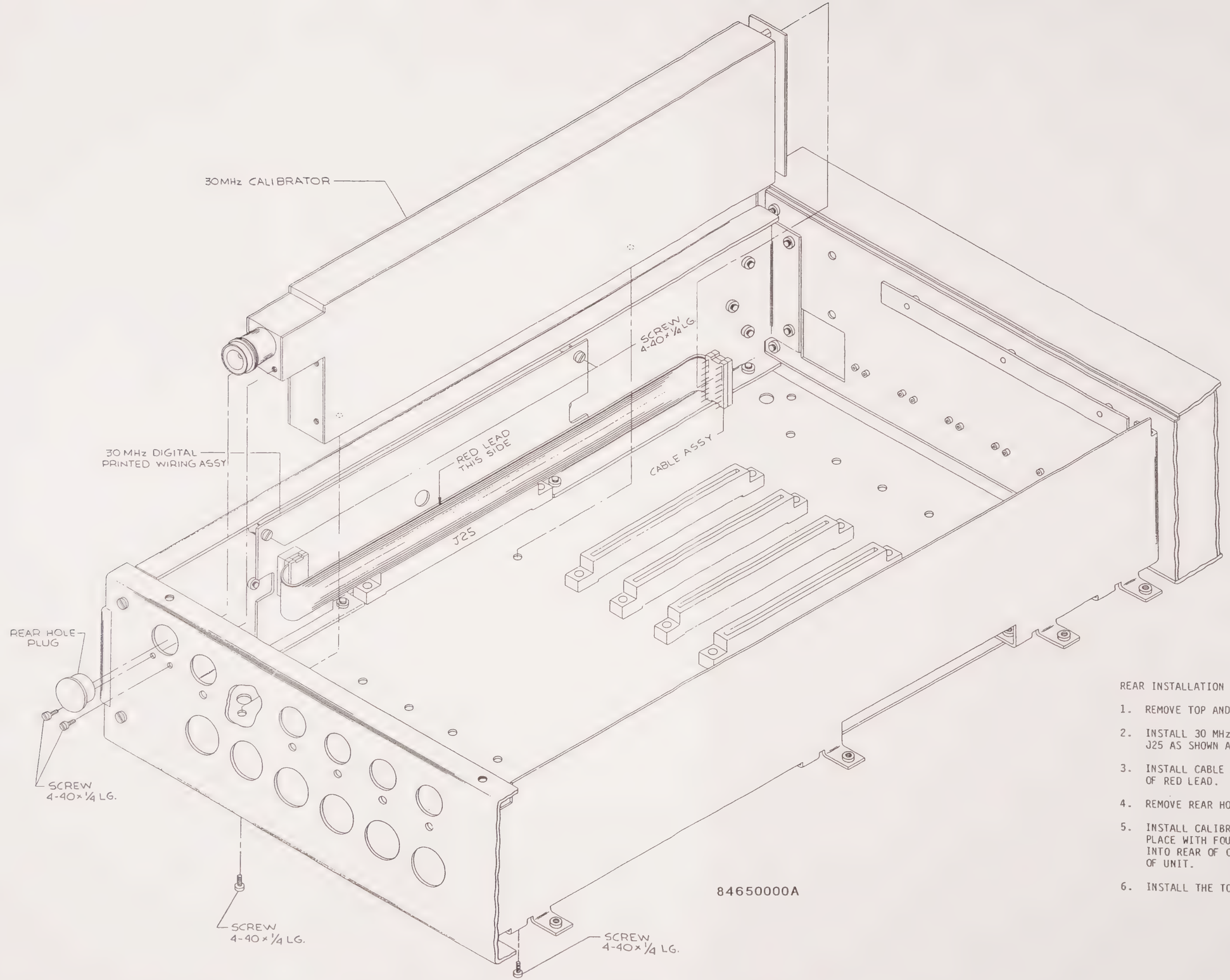
Figure 2-2. Input Module Installation



FRONT INSTALLATION 30 MHz CALLIBRATOR

1. REMOVE TOP AND BOTTOM COVERS.
2. INSTALL 30 MHz DIGITAL PRINTED WIRING ASSY INTO J25 AS SHOWN AND SECURE WITH TWO SCREWS SUPPLIED.
3. INSTALL AND DRESS CABLE ASSY AS SHOWN, NOTE ORIENTATION OF RED LEAD.
4. REMOVE FRONT HOLE PLUG, AND BOTTOM TRIM STRIP.
5. INSTALL CALIBRATOR AS SHOWN, SECURE IN PLACE WITH MOUNTING BRACKET AND FIVE SCREWS SUPPLIED. CONNECT CABLE INTO REAR OF CALIBRATOR WITH RED LEAD FACING BOTTOM OF UNIT.
6. REASSEMBLE TRIM STRIP, TOP AND BOTTOM COVERS.

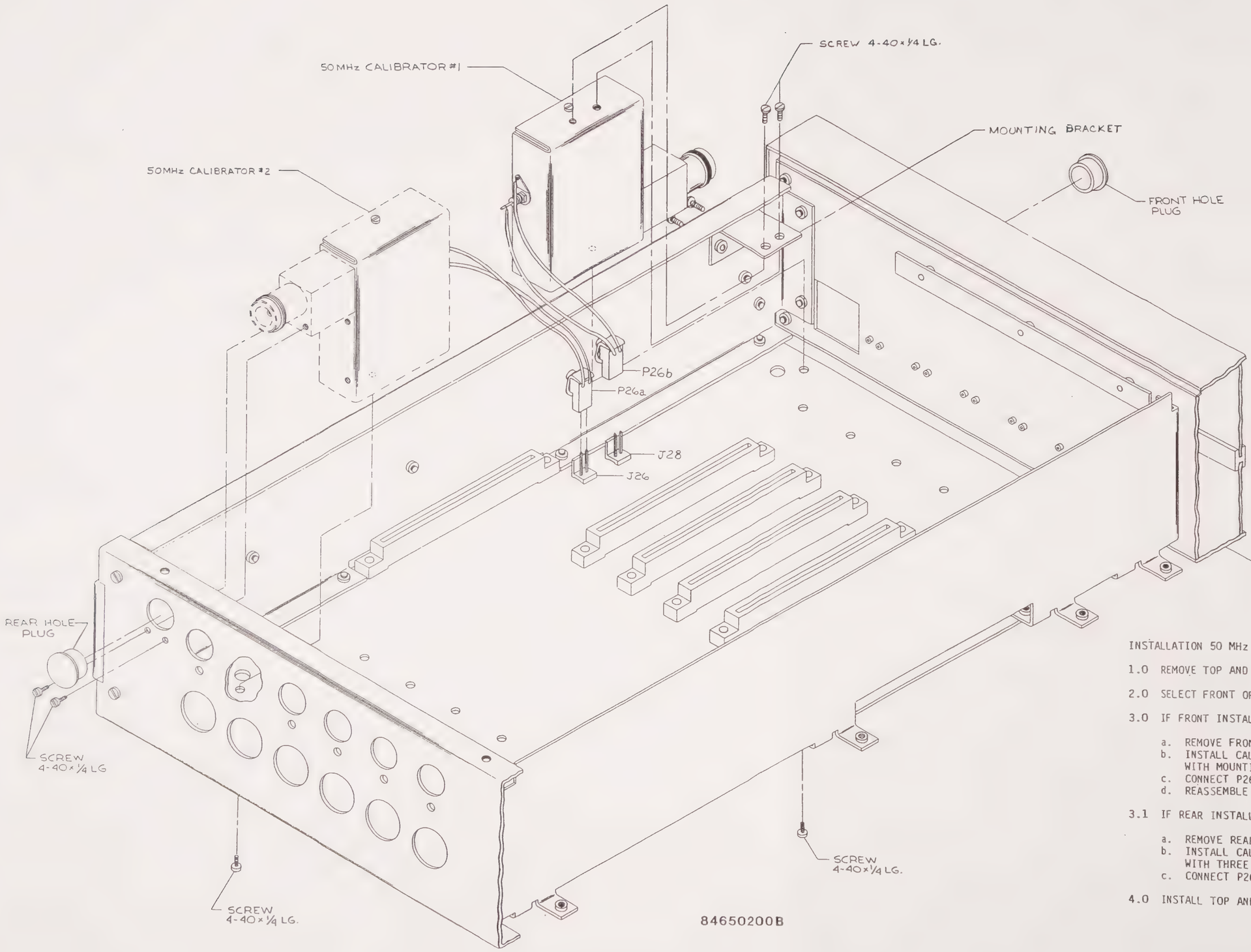
Figure 2-3. 30 MHz Calibrator Installation (Front)



REAR INSTALLATION 30 MHz CALIBRATOR

1. REMOVE TOP AND BOTTOM COVERS.
2. INSTALL 30 MHz DIGITAL PRINTED WIRING ASSY INTO J25 AS SHOWN AND SECURE WITH TWO SCREWS SUPPLIED.
3. INSTALL CABLE ASSY AS SHOWN, NOTE ORIENTATION OF RED LEAD.
4. REMOVE REAR HOLE PLUG.
5. INSTALL CALIBRATOR AS SHOWN AND SECURE IN PLACE WITH FOUR SCREWS SUPPLIED. CONNECT CABLE INTO REAR OF CALIBRATOR WITH RED LEAD FACING TOP OF UNIT.
6. INSTALL THE TOP AND BOTTOM COVERS.

Figure 2-4. 30 MHz Calibrator Installation (Rear)



INSTALLATION 50 MHz CALIBRATOR

1.0 REMOVE TOP AND BOTTOM COVERS.

2.0 SELECT FRONT OR REAR INSTALLATION, OR BOTH.

3.0 IF FRONT INSTALLATION IS SELECTED

- a. REMOVE FRONT HOLE PLUG, AND BOTTOM TRIM STRIP.
- b. INSTALL CALIBRATOR AS SHOWN, SECURE IN PLACE WITH MOUNTING BRACKET AND FIVE SCREWS SUPPLIED.
- c. CONNECT P26 TO J26 or J28 AS SHOWN.
- d. REASSEMBLE TRIM STRIP.

3.1 IF REAR INSTALLATION IS SELECTED

- a. REMOVE REAR HOLE PLUG.
- b. INSTALL CALIBRATOR AS SHOWN AND SECURE IN PLACE WITH THREE SCREWS SUPPLIED.
- c. CONNECT P26 TO J26 OR J28 AS SHOWN.

4.0 INSTALL TOP AND BOTTOM COVERS.

Figure 2-5. 50 MHz Calibrator Installation

SECTION 3
OPERATION

3-1. INTRODUCTION.

Section 3 contains the operating controls, indicators, and connectors, and operating instructions for the Model 4300.

3-2. OPERATING CONTROLS, INDICATORS, AND CONNECTORS.

The controls, indicators, and connectors are listed in Table 3-1 and shown in Figures 3-1, 3-2, and 3-3.

3-3. OPERATING INSTRUCTIONS.

The operating instructions for the Model 4300 are as follows:

1. **Initializing.**
2. **Local Operation.**
3. **Remote (GPIB) Operation.**

3-4. INITIALIZING.

Initialize the Model 4300 as follows:

1. Connect the power cord to the instrument and the desired power source. Refer to Section 2 for the proper power application.

2. Set the LINE ON/OFF switch to ON.

3. Wait a few seconds until the instrument initializes, Press SHIFT, RECALL, 0, ENTER, to set the following conditions:

Single channel, channel 1.
Auto range.
Calibrator Off, level at -60 dBm, max limit at +10 dBm.
dBm mode.
Duty cycle = 100%.
Peak mode disabled.
Frequency = 30 MHz.
dB cal factor = 0 dB.
dB reference = 0 dB.
High limit = 99.99 dBm.
Low limit = -99.99 dBm.

TABLE 3-1. OPERATING CONTROLS, INDICATORS, AND CONNECTORS

Control, Indicator, or Connector	Figure and Index No.	Function
LINE ON/OFF switch	3-1, 1	Switches the AC power ON and OFF.
Display	3-1, 2	Controls the viewing angle.
INSTRUMENT KEYBOARD	3-1, 3	See "SPECIFIC KEY OPERATION".
Channel 1-6 connector	3-1, 4	Used to input from 1 to 6 sensors.
Calibrator connector	3-1, 5	Calibrator output, used to calibrate sensors.
Fuseholder	3-2, 1	AC line fuseholder.
AC connector	3-2, 2	AC power connector.
Line Voltage Selector switch	3-2, 3	Selects the desired operating voltage.
IEEE-488 Bus connector	3-2, 4	Provides a means for connecting the standard IEEE-488 bus interface cable.
Mode switch	3-2, 5	Selects calibration, reset, and misc., options.
Sensor 1-6 connectors	3-2, 6	Used to input from 1 to 6 sensors.
Rec Out 1-6 connectors	3-2, 7	DC outputs 0 - 10 VDC.
Cal Out connector	3-2, 8	30 or 50 MHz calibrator output.

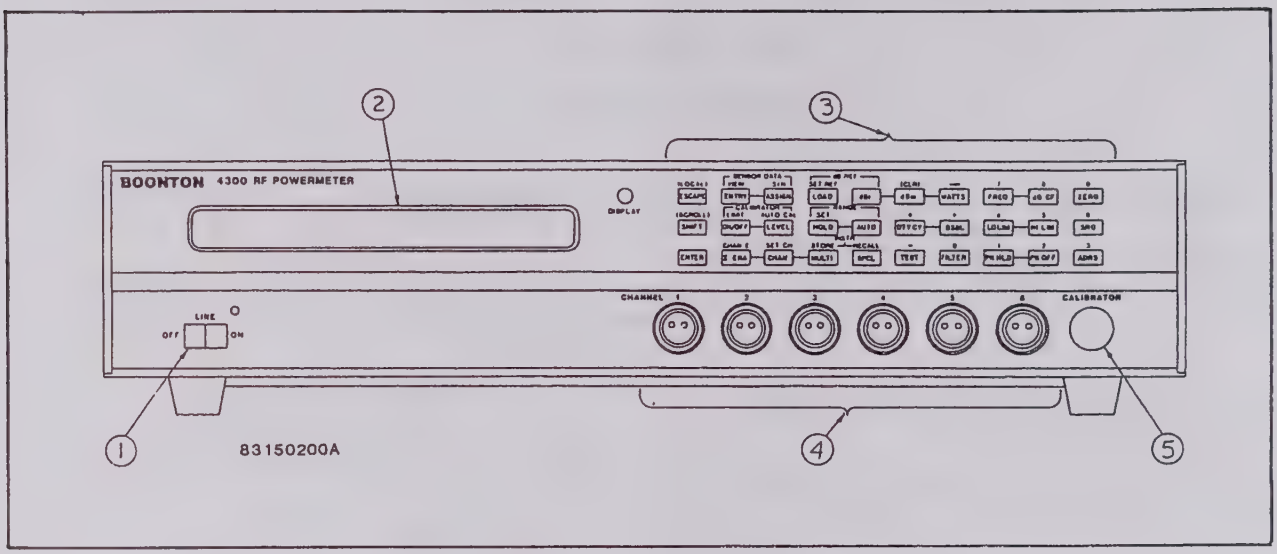


Figure 3-1. 4300 Front Panel

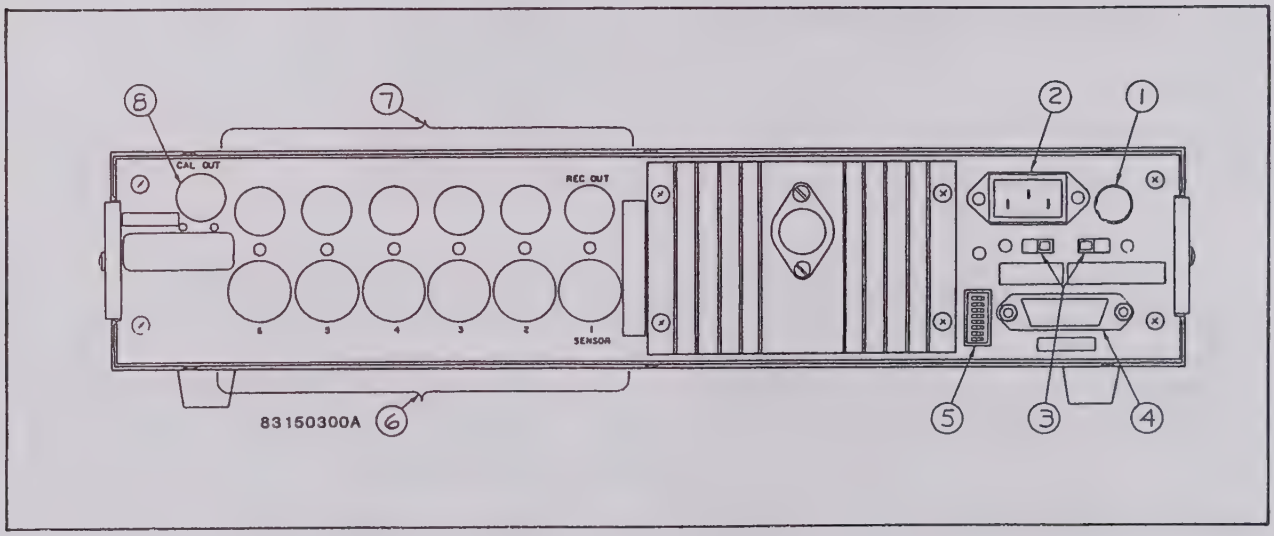


Figure 3-2. Rear Panel

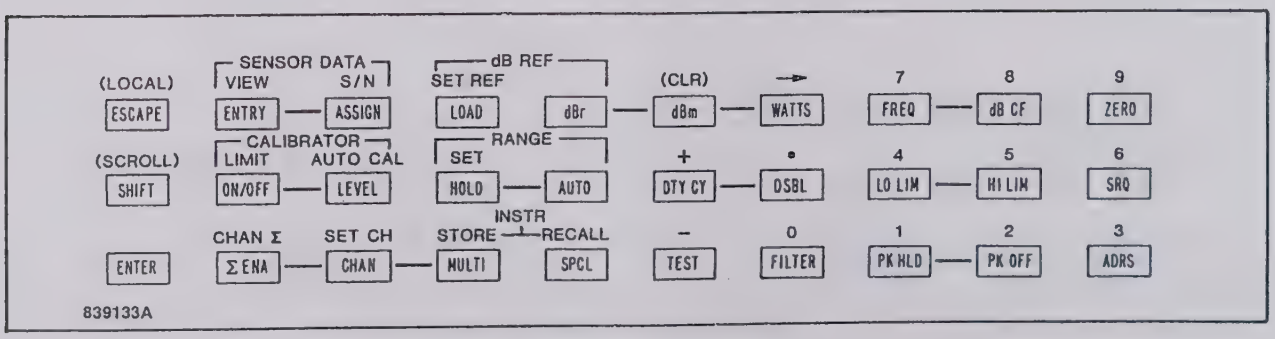


Figure 3-3. Front Panel Keys

Chart recorder scaling from –60 dBm to +20 dBm.
Default filters as shown:

Range	Diode Channels	Thermal Channels
0	2.8 sec	4.8 sec
1	0.8 sec	1.8 sec
2	0.3 sec	0.6 sec
3	.06 sec	0.3 sec
4	.06 sec	-
5	.06 sec	-
6	.06 sec	-

Free run (untriggered) mode.
Channel summation (ratio) set for Ch1-Ch2.
Trigger delay = 130 ms.

3-5. LOCAL OPERATION.

NOTE

Basic operation is shown below. For use of all the functions, refer to Table 3-2, 3-3 and 3-4, and to the section on Specific Key Operation.

3-6. SINGLE CHANNEL OPERATION.

1. Initialize the instrument as described in Section 3-4. This operation does not need to be done every time the instrument is used, because once the instrument is initialized the setup conditions are stored. Also, the rear panel bit switch can be set up so that the instrument initializes every time power is applied (set position 8 to OPEN). Refer to Figure 3-4 for a Single Channel Operation Display (sample).

2. Connect a power sensor, using the supplied cable, to the input channel to be used (front or rear connector). The unused connector for a particular channel should have a grounding cap to prevent noise.

3. Select single channel mode and the channel to be displayed by pressing SHIFT, SET CH, N, ENTER, where N is the channel (1-6) to be selected.

4. Assign the sensor to be used to the channel by pressing SHIFT, SENSOR DATA S/N, XXXXX, ENTER, where XXXXX is the sensor serial number. Alternatively, if the sensor number is known (1 to 20,

TABLE 3-2. CHANNEL PARAMETERS

Parameter	Refer to Key(s)
Range	RANGE SET
Range Mode (hold or auto)	RANGE HOLD, RANGE AUTO
Watts / dBm / dBr Mode	WATTS, dBm, dBr
dB Reference	dB REF LOAD, dB SET REF
Duty Cycle and Duty Cycle Enabled	DTY CY, DSBL *
Peak Hold Enabled	PK HLD, PK OFF
Frequency	FREQ
dB Cal Factor	dB CF
High and Low Limits	HI LIM, LO LIM
Chart Recorder Scaling and Mode	SPECIAL *
Filter Length	FILTER *
Trigger Mode (Free Run, etc.)	SPECIAL *
Trigger Delay	SPECIAL *

*See also Table 3-4.

TABLE 3-3. ADDITIONAL OPERATIONS

Operation	Refer to Key(s)
Zero	ZERO *
30 MHz Calibrator Operation	CALIBRATOR LIMIT, CALIBRATOR ON/OFF, CALIBRATOR AUTOCAL, CALIBRATOR LEVEL
Store and Recall Panel Setups	INSTR STORE, INSTR RECALL
Bar Graph	SPECIAL

*See also Table 3-4.

TABLE 3-4. THEORY OF USE AND APPLICATIONS

Topic	Refer To
Sensor Calibration	Section 4
Zeroing	"
Filtering	"
Measurement Time	"
High Frequency Accuracy	"
Pulsed RF Measurements	"
Chart Recorder Operation	"
Triggered Operation	"
Settled Reading Mode	"

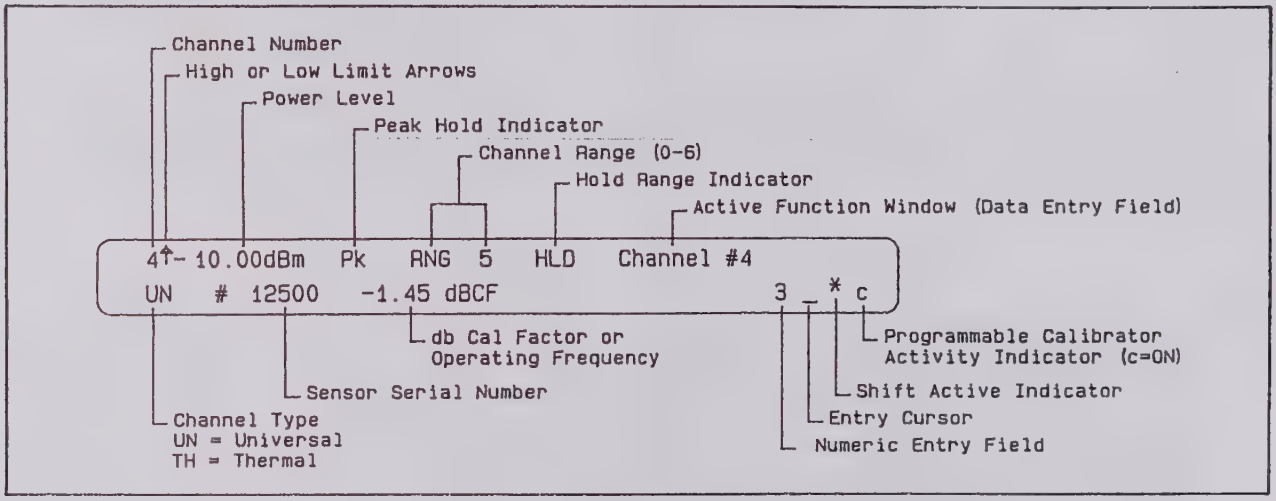


Figure 3-4. Single Channel Display

arbitrarily assigned at the time the sensor data is entered), press ASSIGN, XX, ENTER, where XX is the sensor number. If the sensor data has not been previously entered into the sensor data bank, refer to the SENSOR DATA ENTRY key (instruments are shipped from the factory with the sensor data entered). To view the sensor assignments and/or correlate serial numbers to sensor numbers, press SHIFT, SENSOR DATA VIEW, 1, ENTER. Then press ENTER successively to scroll through the sensors. Press ESCAPE when the desired information is obtained. Once sensor assignments are made, they are retained and are not reset by an initialization (RECALL 0 operation).

5. Connect the sensor to one of the following, as available:

1. 50 MHz internal fixed 0 dBm calibrator.

2. 30 MHz internal programmable calibrator.

3. An external fixed calibrator at 0 dBm or -20 dBm.

6. With the sensor connected to the calibrator, press SHIFT, AUTOCAL. When the display prompts, press ENTER. The ENTER keystroke is a safety measure which prevents accidental erasure of previous autocal data. The 4300 will determine which calibrator is connected if any and do either a fixed or multilevel calibration as appropriate. The multipoint calibration takes about 100 seconds. Calibration should be done when sensors are re-assigned, or when there are temperature changes. Refer to the CALIBRATOR AUTOCAL key for more detailed information.

NOTE

When a 75 ohm sensor is used with the calibrator, compensation must be made for the mismatch. See box "75 OHM SENSOR CALIBRATION" (Section 3-9).

7. Remove the sensor from the calibrator and wait for 10 to 20 seconds. Press ZERO and wait for the 4300

to complete the zeroing routine. Zeroing should be done often when making low level measurements.

8. Connect the sensor to the source to be measured and observe the display.

9. Press the WATTS or dBm keys as required.

10. Refer to Table 3-2 for channel parameters that can be modified, Table 3-3 for additional operations that are not channel parameters, and Table 3-4 for theory of use regarding specific aspects of power measurement and applications.

3-7. MULTICHANNEL OPERATION.

1. In multichannel operation, the channels are in general set up individually, then the instrument is put into multichannel mode, as shown below.

2. Initialize the instrument as described in paragraph 3-4. This operation does not need to be done every time the instrument is used, because once the instrument is initialized the setup conditions are stored. Refer to Figure 3-5 for a Multi Channel Operation Display (sample).

3. Connect the power sensors, using the supplied cables, to the input channels to be used (front or rear connectors). The unused connector for a particular channel should have a grounding cap to prevent noise.

4. For each channel and sensor, perform steps 2 through 8 in the Single Channel Operation procedure, in the single channel mode. Each channel is set up with its own set of parameters. Alternatively, channel parameters that are to be common with all channels can be set up once in multichannel mode.

5. Press MULTI to enter the multichannel mode of operation.

6. Remove the sensors from the calibrator and wait for 10 to 20 seconds. Press ZERO and wait for the 4300 to complete the zeroing routine. Zeroing should be done often when making low level measurements. If some of the channels cannot zero due to a large offset (as in the case of no sensor connected), an error message will be generated. Pressing ESCAPE will clear this, however, the channels that are able to zero will zero. If it is desired to zero only one channel, the instrument can be put in single channel mode and zeroed, and returned to multichannel mode before that channel has completed zeroing.

7. Connect the sensors to the sources to be measured and observe the display.

8. Press the WATTS or dBm keys as required. Some channels can be in Watts while the others are in dBm or dBr.

9. The channel parameters listed in Table 3-2 can be entered simultaneously for all channels in multichannel mode. If it is desired to enter a parameter for one channel only, put the instrument temporarily in single channel mode on the channel desired, set the parameter, and return to multichannel mode.

10. The display shows the multiple power readings only; if more specific information is desired, such as range or frequency, the data can be extracted by going back to single channel, or by pressing the parameter key in question. For example, to view the operating frequency, the frequency key can be pressed. If the channels are operating on different frequencies, the display field for frequency will be blank, because no single frequency applies.

11. Refer to Table 3-3 for additional operations that are not channel parameters, and Table 3-4 for theory of use regarding specific aspects of power measurement and applications.

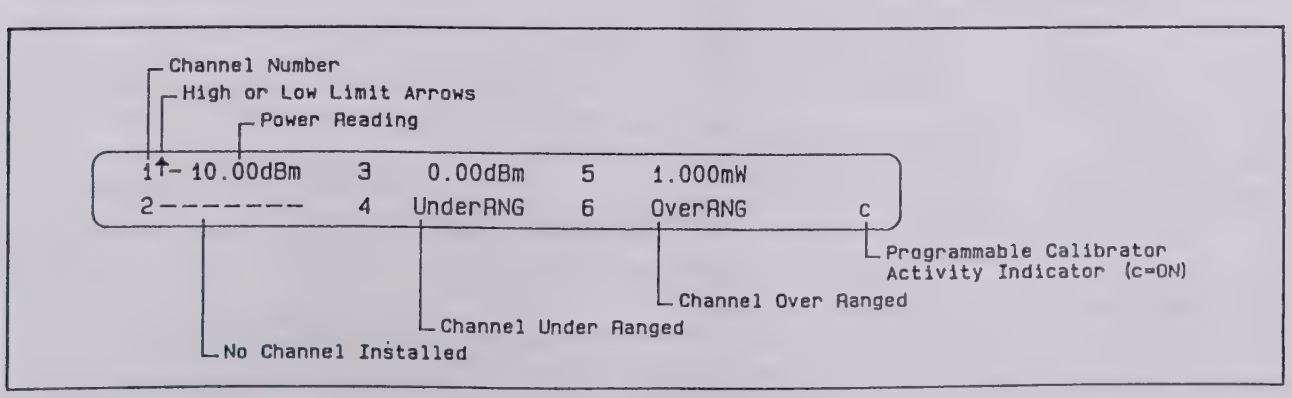


Figure 3-5. Multichannel Display

3-8. SUMMATION OPERATION.

NOTE

The summation operation is basically a subset of multi-channel operation in that several channels are in operation. Most of the operating procedures for multi-channel operation are applicable to summation operation. Summation operation is set up by setting up the channels one at a time in single channel operation (entering sensor data, etc.), then verifying proper operation of all channels in multi-channel operation, and then entering the summation equation, followed by the steps below.

1. Refer to Section 3-7, Multi-Channel Operation and perform steps 1 through 10. Refer to Figure 3-6 for a Summation Operation Display (Sample).

2. Enter the summation equation. Press SHIFT, CHAN **E**, and the equation, in the form a+b+c+d+e+f etc., where a, b, c, d, e, and f correspond to channels 1 through 6, ENTER.

Example:

Press SHIFT, CHAN **E**, 1, +, 2, -, 4, ENTER. The total can be displayed in either watts or dBm, (in watts the equation becomes a ratio, that is, powers are divided and multiplied).

3. To perform the summation equation press **E** ENA. The display will indicate the resulting dB difference or power ratio, along with the equation.

4. Press dBm or dBr to display the difference in dB.

5. Press WATTS to display the power ratio. Ratio is expressed in percent from 99.999% to .0001%.

6. To return to multi-channel operation Press MULTI.

3-9. 75 OHM SENSOR CALIBRATION.

When a 51012 or other 75 ohm sensor is used with the 4300, the following procedure must be used for calibration, either with the fixed 50 MHz 0 dBm calibrator or with the adjustable 30 MHz calibrator.

The calibrators have 50 ohm outputs. There are three methods to handle the mismatch:

1. With a 50 to 75 ohm transformer. With this method there is a fixed loss which must be measured (generally this loss is about .05 to 0.1 dB), and entered as a correction factor as shown below.

2. With a minimum loss resistive attenuator (50 to 75 ohms). With this method there is a fixed loss of 1.76 dB and the VSWR is held to a low value. The loss must be entered as a correction factor as shown below. This method is generally not as accurate as the other two methods unless the attenuation of the pad is known exactly.

3. With a straight through 50 to 75 ohm adapter, Boonton P/N 950006, which is a mechanical adapter only (no resistors). This is the preferred method. The 75 ohm type N connector has a different diameter center pin than the 50 ohm unit. With this method, the loss due to mismatch is 0.17 dB and it must be entered as a correction factor as shown below.

3-10. CORRECTION FACTOR ENTRY (75 OHM SENSORS)

Enter the loss as a positive number in dB REF (use SET REF key) before calibration. Then when taking measurements, disable the dB REF by setting the units to dBm, or by setting dB REF to zero, or both. The instrument has calibrated taking the reference into account; it is not lost. Now the dB REF function can be used as normal. Note: When the 30 MHz adjustable output calibrator is used in the 4300, the instrument will automatically set dB CF to zero during the autocalibration

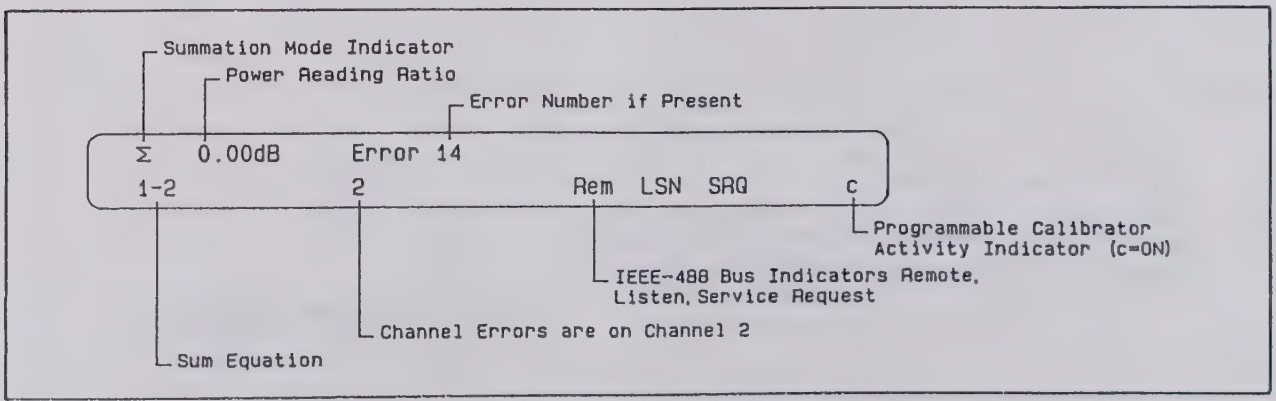

Summation Mode Indicator
Power Reading Ratio
Error Number if Present
Σ 0.00dB Error 14
1-2 2 Rem LSN SRQ C
Programmable Calibrator Activity Indicator (c=ON)
IEEE-488 Bus Indicators Remote, Listen, Service Request
Channel Errors are on Channel 2
Sum Equation

Figure 3-6. Summation Display

cycle. This is why dB CF can't be used to enter the correction factor. Fixed calibration at (0 or -20 dBm) however, does incorporate the dB CF, to accommodate calibration of mm Wave sensors at levels known to be nonexact. Therefore, when using fixed calibration, the correction factor may be entered into either dB CF or dB REF. The limit on entries in either parameter is +/- 3 dB.

3-11. SPECIFIC KEY OPERATION.

Each of the keys is described in detail below.

3-12. ESCAPE Key. Pulls the 4300 out of any of the menu-driven sequences (sensor entry, summation, equation, etc.) and all implied shifts, and prompts. Clears the right-hand data entry field of the display. Returns the instrument to measurement mode. Serves as a general purpose clear which can be used before initiating any function. Also performs the local function. (The two operations are identical.)

3-13. SHIFT Key. Illuminates a lower case "x" located on the lower right hand side of the display, to indicate the shifted function, and sets the unit up to accept the panel marking function above particular keys. However, numbers are not entered using shift since they always follow a prompt, which builds in, or implies a shift. For example, to set range 5, press SHIFT, RANGE SET, 5, ENTER. The shift key need not be pressed before the "5" because the RANGE SET key automatically actuates the shift. (CLR, ., +, -, and ← are implied shift keys also.)

3-14. 0 through 9 Keys. Numeric entry keys. The SHIFT key need not be pressed first.

3-15. =, -, and • Keys. Used for numeric sign and decimal entry.

3-16. ← (BACKSPACE) Key. Used in numeric entry routines to "erase" inadvertent panel entries.

Operation	Press	Display Shows
Backspaces numeric entries	←	Any wrong entry erased

3-17. (CLR) Key. Clears the entire numeric entry when in entry mode, but leaves the function active for new input.

3-18. ENTER Key. Terminates a numeric entry.

3-19. SCROLL Key. In the sensor entry and view modes, and in some of the Special and Test modes, the SCROLL key advances the menu items or scrolls through sensor data types as applicable. Scroll is an implied shift; that is, when scrolling is allowed, the SHIFT/SCROLL key will automatically become a scroll key.

3-20. (LOCAL) Key. Returns the instrument to local (front panel) mode. Can be disabled by the local lockout mode over the bus. Also performs the escape function. The parenthesis around the LOCAL on the (LOCAL) key signifies that when the (LOCAL) key is pressed, the shift is implied, and the SHIFT key does not have to be pressed.

Operation	Press	Display Shows
Aborts remote operation and returns control to the keyboard	(LOCAL)	—

3-21. SRQ Key. In the appropriate bus modes, will generate an SRQ for manual triggering of data onto the GPIB Bus and on the display. It is activated by setting the SRQ mask byte. Refer to the GPIB Section.

Operation	Press	Display Shows
Sets the SRQ flag	SRQ	

3-22. ADDR Key. Prompts the user for the GPIB address. The limits are 0 - 31.

Operation	Press	Display Shows
Views or changes the bus address	ADDR	Current number
	nn	Desired number
	ENTER	

3-23. ZERO Key. Zeros all displayed channels. If the power is above a preset limit on a particular channel (roughly a full scale signal on range 0), the channel will not zero but instead, give an error message. A 2 second delay is provided after the zero key is depressed, to let the sensor decay. However, more time may be necessary at low levels. Refer to Section 4. Zeroing takes from 8 to 20 seconds depending on the filter selected. In multichannel mode if it is desired to zero just one channel, the operator can put the unit into single channel and press ZERO, then multichannel mode can be recalled while that channel is still zeroing. The chart recoder output can be set up as a TTL signal that is active while the 4300 is zeroing, for purposes of disabling the source. Refer to Section 4.

Operation	Press	Display Shows
Zero (single or multichannel)	ZERO	Checking, Settling, Zeroing, (in sequence)

3-24. TEST Key. Prompts the user for a number (1-7), when entered runs through various diagnostics. The tests available are as follows: (Refer to Section 6, Maintenance for a more detailed description.)

NOTE

To display the Test Option Menu, press TEST, then (SCROLL). Seven tests are available, therefore; each time the (SCROLL) key is pressed one test is displayed.

TABLE 3-5. SPECIAL FUNCTIONS

SPECIAL #			
1	Trigger Mode Setup Refer to Section 4 for Triggered Operation.	0 — Free Run Mode 1 — Free Run Filtered Mode 2 — Free Run Settled Mode 3 — Trigger Filtered Mode 4 — Trigger Settled Mode 5 — Trigger Delay (130 ms default)	(Numbers 0 through 4 activate a Trigger Mode; Number 5 prompts the operator for a number.)
2	Recorder Output Scaling. Refer to Section 4 for Chart Recorder Operation.	0 — Sets bottom (0V) 1 — Sets top (10V) 2 — Summation assignment 3 — Recorder off 4 — Zero indicator 5 — HI/LO limit indicator 6 — Raw value 7 — Measurement mode 8 — Recorder DC Level	
3	DC Calibration Factor Entry/Edit	The DC calibration data points are gain factors for the channel cards, one point for each of the 7 ranges and one additional point for A/D adjustment. This function allows the user to view this data and change it if necessary. The data being worked with is that on the currently selected channel card. Refer to Section 6. This data can be protected to prevent alteration from the front panel by the use of position 2 on the internal Bit switch. See Table 6-202.	
4	DC Calibration Factor Calculation	The DC calibration data points are gain factors for the channel cards, one point for each of the 7 ranges and one additional point A/D adjustment. This special function allows an automatic computation of the gain factors when calibrating. Refer to Section 6. This data can be protected to prevent alteration from the front panel by the use of position 2 on the internal Bit switch. See Table 6-202.	
5	AC 14 Point Calibration	This function generates linearity data, referred to as 14 point upscale/downscale data, for coaxial sensors that are to be used on a Boonton 4200 Power Meter. There are seven upscale points (one per range) and seven downscale points. To use this function, place the 4300 in the single channel mode and connect the sensor to the programmable 30 MHz Calibrator. Assign a sensor number (1-20) that is not currently used and enter the sensor type, then press SPCL, 5, ENTER. When the generation of data is complete, the 14 point data may be extracted by pressing the SENSOR DATA ENTRY key.	
6	Recalibrate Programmable Calibrator	The programmable calibrator can be field calibrated. Refer to Section 6. This data can be protected to prevent alteration from the front panel by the use of position 2 on the internal Bit switch. See Table 6-202.	

TABLE 3-5. SPECIAL FUNCTIONS (Cont.)

SPECIAL #		
7	Bar Graph Toggle ON/OFF	The bar graph is a 40 division power level indicator that appears only in single channel mode when activated. It works as a linear graph when the channel is in watts and logarithmic when the channel is in dBm or dBr. The scale of the graph is programmable and uses the chart recorder operating parameters as its scale factor. For the bar graph to work properly the chart recorder should be in the measurement mode (7). To set the scale see chart recorder operation in Section 4.
8	Raw Value Mode	The value displayed in this mode is the A/D level from the input channel representing the digitized sensor voltage before any shaping or adjustments are made to it. Its range is 0 to 8192 over each of the seven ranges. The raw value mode is used in diagnostics and calibration routines. The raw value mode is disabled by pressing dBm, dBr, or Watts.
9	Trigger	This command allows the operator to perform a trigger from the front panel of the instrument. This command is active only when the instrument is already in one of the trigger measurement modes.
10	Measurement Status	The measurement status command activates a temporary display which shows the current measurement mode, if fixed point cal is active, and if multi-point cal is active. It indicates the status of the last single channel that was selected.

Test	Description
1	Keyboard Test
2	Display Test
3	Memory Test
4	Bit Switch Test
5	GPIB Bus Test
6	Software ROM Revision Numbers
7	Battery Test

3-25. SPCL Key. Prompts the user for a number (1-10) and goes into special modes according to Table 3-5.

NOTE

To display the Special Functions Menu, press SPCL, then (SCROLL). Ten tests are available, therefore; each time the (SCROLL) key is pressed a Special Function will be displayed. Enter the Special Function number and press the (SCROLL) key again to display the Special Function sub-modes.

3-26. FILTER Key. Prompts the user for the digital filter length in milliseconds from 20 to 20,000 mS in 20 mS increments. Uneven increments are accepted and rounded off to the nearest 20 ms. Entering "0" will default the filter(s) to preset lengths which have been chosen to optimize speed and accuracy. Refer to the INSTR RECALL key description for the default conditions. The default values are a function of range and input channel type (universal or thermal). The filter key also calls up the current length on the display, whether internally generated or user set. The filter entries apply to all displayed channels, but in multichannel mode, the recalled number on the display will be blank if the filter lengths are not equal on all channels. Refer to Note 1. (If the default filters are applied to all channels, but the channels are on different ranges, the display will be blank.) Refer to Section 4 for more detailed filtering information.

Operation	Press	Display Shows
Views/changes filter	FILTER	Present filter in mS
	Desired time in mS	Desired filter in mS
	ENTER	

NOTE 1

This function affects all displayed channels whether in single or multichannel operation. Changing from multi-channel to single channel does not affect the status of this parameter on any channel. For example, in multichannel, to set this parameter on any one channel, go to single channel, set it, and go back to multichannel. The channel parameters are: range, range mode, (hold or auto), frequency, filter length, dB-cal factor, high and low limits, duty cycle, peak hold enabled, chart recorder scaling, units (Watts, dBm, dBr), dB reference, trigger mode, and trigger delay.

3-27. FREQ Key. When the FREQ key is pressed, the display will prompt the user for frequency. Frequency is entered in GHz from .01 to 110 GHz. The 4300 then looks up the appropriate high frequency cal factor for each sensor that has been assigned, linearly interpolating between points as required. In multichannel mode if a frequency outside the range of any sensor is entered, an error message is displayed showing the affected channel(s). If the sensor frequency ranges do not overlap, entering a frequency in multi-channel mode is not valid. Error messages will not be generated for uninstalled channels. Refer to Note 1 above.

3-28. dB CF Key. When it is desired to enter the high frequency cal point directly rather than retrieve/interpolate it from the sensor data, this key may be used. Entry is limited to ±3 dB in .01 dB steps. Also, this key can be used to recall the frequency cal factor that has been retrieved/interpolated by use of the sensor tables. Refer to Notes 1 and 2.

NOTE 2

When autocalibrating with the programmable 30 MHz Calibrator, dB CF will automatically be set to zero.

Operation	Press	Display Shows
View/change calibration factors	dB CF	Present value of offset in dB
	Value in dB	Desired value in dB
	ENTER	

3-29. DTY CY Key. Prompts the user for the duty cycle in % from 100% to .0001%. Puts the displayed channels in pulse power mode. Essentially divides the power by the duty cycle, although correction factors are added in for diode sensors at the top of the square law region. In single channel mode, both peak and average powers are shown along with the duty cycle and additional messages for more information. In multichannel mode only the pulse powers are displayed. The high and low limits, if set, apply to the average power. The dB REF and dB LOAD keys still operate normally. The pulse power mode is disabled by pressing DSBL. Refer to Section 4 for detailed information regarding pulse power measurements. Refer to Note 1 above.

Operation	Press	Display Shows
Pulse power calculation (duty cycle)	DTY CY	
	nn.nnnn	
	ENTER	Duty cycle, average, and pulse power in watts, dBm, or dBr, and the region of diode sensors (square-law, transition, or peak) In multichannel only the pulse powers are shown

3-30. DSBL Key. Disables the pulse power mode. Refer to Note 1 above.

Operation	Press	Display Shows
Disables pulse power mode	DSBL	Average power(s)

3-31. LO LIM Key. Used for go/no-go tests. Prompts the user for a low limit in dBm from -199 to +199 dBm. When entered, if the measured power is below the limit, the display will indicate a flashing down arrow to the left of the power. Although the limit entries must be entered in dBm, the limits still work in dBr, dBm and watt modes. The limit entries affect all the displayed channels, and operate on the displayed value (i.e., in dBr mode, the reference is taken into account). The out of limit condition can be outputted on the chart recorder as a level, by pressing SPCL, 2, ENTER, 5, ENTER. Refer to Section 4, Chart Recorder Operation. Refer to Note 1 above.

Operation	Press	Display Shows
Sets the low limit (in dBm)	LO LIM	Low limit value in dB
	Desired value in dB	Desired value in dB
	ENTER	

3-32. HI LIM Key. Similar to LO LIMIT. The high limit is -199 to +199 dBm. When the high limit is exceeded, a flashing up arrow is indicated. The HI LIMIT entry must be larger than the LO LIMIT entry. Refer to Note 1 above.

Operation	Press	Display Shows
Sets the high limit (in dBm)	HI LIM	High limit value in dBm
	Desired value in dBm	Desired value in dBm
	ENTER	

3-33. PK HLD Key. When this function is enabled, each measurement is compared to the previous reading and the highest of the two is held and displayed. The effective sampling time is 25 mS/channel typically (150 mS for 6 channels). Resetting is accomplished by pressing PK HLD again. To disable press PK OFF. Applies to all displayed channels. Not related to pulse power mode. Refer to Note 1 above.

Operation	Press	Display Shows
Peak hold	PK HOLD	Peak power in dBm, dBr, or watts on all displayed channels

3-34. PK OFF Key. Disables the peak hold functions. Refer to Note 1 above.

Operation	Press	Display Shows
Peak hold disable	PK OFF	Average power(s)

3-35. CHAN E Key. Prompts the user for the summation equation. Entry is in the form of an equation, for example 1-3+6 ENTER (dB mode). In watts mode, the +/- keys are still used but are displayed as multiply/divide signs. The (CLR) and backspace (←) keys operate in the same manor as for numeric entry. See **E** ENA key.

Operation	Press	Display Shows
Enter the summation equation	SHIFT, CHAN **E**	Sum **E** equation
	1, -, 3, +, 6	
	ENTER	

3-36. E ENA Key. Puts the unit in the summation channel mode. Displays the summation equation, (up to 6 channels), for example 1+3-4 (in dB mode), and the result in dB. In power mode, the +/- signs are displayed as divide/multiply, for ratio purposes. Ratio is shown in % from 0.1% to 99,999% (1000:1 or 1:1000). A general purpose error message is generated if a channel is over/under range, has exceeded HI/LO limits, etc. The message indicates which channel has the problem. The CHAN, MULTI, and **E** ENA keys are mutually exclusive.

Operation	Press	Display Shows
Enables the summation mode	**E** ENA	The summation equation and the sum or difference in dB, or the ratio in %

3-37. SET CH Key. Prompts the user for a channel (1-6) to be viewed.

Operation	Press	Display Shows
Selects a specific channel	SHIFT, SET CH	Present channel number
	n (1-6), ENTER	Selected channel

3-38. CHAN Key. Puts the unit in single channel mode on the last channel that was selected. The CHAN, MULTI, and **E** ENA are mutually exclusive.

Operation	Press	Display Shows
Displays the last single channel selected	CHAN	The last single channel selected

3-39. MULTI Key. Puts the unit in 6 channel mode. Channel slots that are not filled are shown with dashes on the display. Channel parameters that are entered in this mode (such as frequency, filter, etc.) are applied to all channels. Channel parameters that are called up on the display will only be shown if the parameter is identical for all 6 channels. The CHAN, MULTI, and **E** ENA are mutually exclusive.

Operation	Press	Display Shows
Displays 6 channels	MULTI	Power in watts, dBm or dBr for 6 channels

3-40. SENSOR DATA VIEW Key. This key is used to provide a quick summary of any one of the 20 sensors, showing type, serial number, and to which channel it is assigned if any. When pressed, the 4300 prompts the user for the sensor number (1-20). Pressing enter starts viewing the sensors starting with this one. The SHIFT/(SCROLL) key is used to advance to the next sensor and the ESCAPE key is used to exit back to the main level (measurement mode).

Operation	Press	Display Shows
Views sensor S/N, type, and channel assignment	SHIFT SENSOR-VIEW 3	
	ENTER	Sensor # (3 for this example), type, serial #, channel(s) that it is assigned to
	SCROLL	Sensor # (4 for this example), type, serial #, channel(s) that it is assigned to
	ESCAPE	

3-41. SENSOR DATA ENTRY Key. Initiates the routine for entering sensor calibration data, sensor type, and serial number into the sensor bank (1-20 sensors). Refer to Section 4 for a more detailed explanation of what the calibration data is. Pressing this key prompts the user for a sensor number (1-20) for which cal data is to be modified. (The default number that is displayed is the sensor currently assigned to the selected channel.)

NOTE

To unprotect sensor data set the rear panel switch (position 6) to closed and set the internal switch on the control board (position 3) to open. The switches may be left in the unprotected mode if desired.

Once the sensor is selected, a sub-mode is entered which allows data to be examined or altered. There are 6 types of data that can be entered as listed below. The 4300 prompts the user for each type of data. At any point in data entry, the ESCAPE key will clear the sub-mode and exit to the measurement mode. Data entered up to that point will be retained. The (SCROLL) key can be used to advance to the beginning of the next section without having to pass through each entry. The RECALL key can be used to back up to the last entry in a particular section.

1. **Sensor Type.** The first data to be entered is the sensor type which is a 5 digit number. Cross reference to Boonton 4200 sensor types is shown in Table 3-6 and is also viewed in menu form with the (SCROLL) key.

TABLE 3-6.

4200/4300 SENSOR CROSS REFERENCING	
4200	4300
4200-4A	51010
4200-4B	51011
4200-4C	51012
4200-4E	51013
4200-4G	51051
4200-5B	51014
4200-5E	51015
4200-6E	51033
4200-7E	51016
4200-8E	51017
4200-4K	51035
4200-4KA	51036
4200-4Q	51037
4200-4U	51045
4200-4V	51046
4200-4W	51047
51972-WRD-180	51972

2. **Serial Number.** The second data to be entered is the sensor serial number, which is located on the sensor label. Enter the number from 0 to 999,999, and press ENTER.

3. **Upscale Data Points.** Supplied with each sensor is a group of 7 upscale calibration factors (4 for thermal sensors), one for each range. Alternatively, these numbers can be generated with the "14 point calibration data routine". These numbers linearize the sensor. (If the 30 MHz autocalibration cycle is to be used, upscale and downscale points do not need to be entered.) Refer to Section 4 for information on the use of these numbers. These numbers are entered at this point in the sensor entry routine. The range of valid numbers is 4200 to 5800 with 5000 being the nominal calibration (default value). The 4300 prompts the user for an upscale number on each range and then proceeds to the downscale data points.

NOTE

If it is desired to skip the upscale and downscale points and go right to the frequency cal points, SCROLL can be pressed.

4. **Downscale Data Points.** Also supplied with each sensor is a group of downscale points which are entered with the same procedure as the upscale data points. The number range is from -200 to +200.

5. **Frequency Cal Points.** Supplied with each sensor is a list of high frequency cal points (also referred to as dB Cal Factor points), which consists of a pair of data values for each point. This information must be entered in order starting with the lowest frequency. The number of the cal point (table entry) is displayed as "TBL#" during this entry procedure. When the frequency cal points have been entered, pressing ESCAPE will return the 4300 to its normal operating mode.

NOTE

Sensors 1 through 6 allow up to 80 cal points, while entries 7 through 20 allow up to 35 points.

a. The first part of the pair is frequency with the units in GHz. The range of accepted values is from 0.0 to 110 GHz in .01 GHz increments. Sensors are generally supplied with their first cal point at 1 GHz. If frequencies below the first cal point are to be used in operation, a starting point should be entered at 0 GHz, 0 dB CF.

b. The second part of the pair is the cal factor in dB. The range of acceptable correction factors is from +3 to -3 with two decimal places (.01 dB resolution).

c. Example: The procedure below shows the entire sensor entry procedure.

Operation	Press	Display Shows
Enter sensor data for one sensor into the sensor bank (1-20)	SENSOR-ENTRY	
	18	
	ENTER	Enter type
	SCROLL	
	SCROLL	51013
	51013	

Operation	Press	Display Shows
NOTE: This example enters a type 51013 sensor, S/N 12345, into location 18. The upscale calibration factors are 5204, etc. The downscale factors are -17 etc. A cal point of 1.20 dB at 2 GHz has been entered and also a point of 1.4 dB at 3.5 GHz. When the ENTER key is pressed, the display advances to the next frequency or cal factor, recalling the previous data entry, which is zero for an unloaded sensor. the serial number, upscale or downscale points, or frequency cal points can be bypassed by pressing SCROLL.	ENTER	Serial #
	12345 ENTER	Upscale, RNG 0
	5024 ENTER	Upscale, RNG 1
	5024 ENTER	Upscale, RNG 2
	5103 ENTER	Upscale, RNG 3
	4984 ENTER	Downscale, RNG 0
	-17 ENTER	Downscale, RNG 1
	.	.
	.	.
	.	.
After entering the data, the sensor must be assigned to a channel Refer to SENSOR ASSIGN key.	-8 ENTER	Downscale, RNG 6
	-6 ENTER	FREQ 0.00 GHz, TBL #00
	2 ENTER	CAL FACTOR 0.00. TBL #00
	1 22 ENTER	FREQ 0.00 GHz, TBL #01
	RECALL	CAL FACTOR 1.22, TBL #00
	1.20 ENTER	FREQ 0 00 GHz, TBL #01
	3.50 ENTER	CAL FACTOR 0.00, TBL #01
	1.40 ENTER	FREQ 0 00 GHz, TBL #02
	ESCAPE	(measurement mode)

3-42. SENSOR S/N Key. This key prompts the user for a 1 to 6 digit number which is used to search through all 20 sensor serial numbers for a match. If it is found assigns that sensor to the currently selected channel. Used in place of the ASSIGN key. Must be used in the Single Channel Mode.

Operation	Press	Display Shows
Assigns a sensor to a channel using sensor S/N	SHIFT SET CH 5	
	ENTER	Channel 5 power, etc
	SENSOR S/N 12045	
	ENTER	Channel 5 power, etc The assignment can be verified by using the VIEW key

NOTE

When a channel is reassigned a new sensor, or when a sensor is reassigned to a channel that is already assigned to, the following actions occur:

1. The operating frequency and dB CF are set to 0.

2. The Auto-calibration Data is erased (linearity data that was generated with the 30 MHz Programmable Calibrator).

3. The fixed point (0 dBm or -20 dBm) calibration data is erased.

3-43. This method of erasing calibration data (items 2 and 3 above) covers the case where a coaxial sensor is replaced with a mm wave sensor, which generally cannot be field calibrated. None of the sensor data stored in the sensor bank is lost (includes 14 point linearity data and high frequency cal factors).

3-44. SENSOR ASSIGN Key. This key is used to assign a sensor to the currently selected channel by sensor number (1-20) (the 4300 must be in single channel mode). One sensor can be assigned to several channels, however, each channel can only have one sensor assigned to it.

Operation	Press	Display Shows
Assign sensor 16 to channel 2	SHIFT SET CH 2	
	ENTER	Channel 2 power, etc
	SENSOR ASSIGN 16	
	ENTER	Channel 2 power; the assignment can be verified by pressing the VIEW key

3-45. dB REF SET Key. Prompts the user for a reference level that all subsequent measurements are referred to. For example, if the dB reference is -20 dBm and the measurement power is -30 dBm, the display will indicate -10 dBr. This function applies to all channels that are in dBr mode only. Disabling but not deleting the reference is accomplished by pressing dBm or WATTS, (the reference is saved). Resetting the reference is accomplished by pressing dB REF SET, 0, ENTER. The dB CF function still operates normally and independently. The dB REF SET key also activates the dBr function. (dBr does not need to be pressed after entering the reference). Refer to Note 1 above. The acceptable range of this value is -100 dB to +100 dBm.

Operation	Press	Display Shows
Sets a dBr reference	SHIFT, SET	dBr (present value)
	Desired value in dBm	Desired value
	ENTER	

3-46. dB REF LOAD Key. Takes the present measured value and uses it for a reference for all subsequent measurements. Pressing this key will set the display to 0.00 dBr for all valid power conditions. Disabling (but not deleting) the reference is accomplished by pressing dBm or WATTS. Resetting the reference is accomplished by pressing dB SET, 0, ENTER. The reference for each channel is independent. Refer to Note 1 above. This key also activates the dBr function (dBr does not need to be pressed after pressing load).

Operation	Press	Display Shows
Loads a dBr reference	SHIFT	0 00 dBr
	dB REF LOAD	

3-47. dBr Key. Puts all the displayed channels in dB reference mode. Uses the references that were loaded or set with dB REF LOAD or dB REF SET. Each channel has its own reference. Refer to Note 1 above.

Operation	Press	Display Shows
Displays power in dBr	dBr	Value in dBr

3-48. dBm Key. Puts all the displayed channels in the dBm mode, disabling the dB reference that was previously entered. The dB reference is still saved. Refer to Note 1 above.

Operation	Press	Display Shows
Displays power in dBm	dBm	Value in dBm

3-49. WATTS Key. Puts all the displayed channels in the "watts" mode (mW, uW, etc.). The dBr reference that had been entered previously is not incorporated into the reading; however, it is still saved.

Operation	Press	Display Shows
Displays power in Watts	WATTS	Value in Watts

3-50. CALIBRATOR LIMIT Key. Sets the limit of the 30 MHz calibrator, for sensor protection purposes. The upper limit overrides subsequent level entries that are too high. When this key is pressed, the message CAL LIMIT and the present limit are displayed. The values that can be entered must be between -60 to +20 dBm, in 1 dB steps.

Operation	Press	Display Shows
Sets calibrator maximum output	SHIFT LIMIT	Present calibrator limit in dBm
	Desired limit in dBm	Desired calibrator limit in dBm
	ENTER	

3-51. CALIBRATOR ON/OFF Key. Toggles the 30 MHz calibrator output on and off. A lower case "c" is displayed in the lower right corner of the display when the calibrator is on.

Operation	Press	Display Shows
Turns the calibrator on or off	ON/OFF	c when ON blank when OFF

3-52. CALIBRATOR AUTO CAL Key. When this key is pressed, the 4300 initiates an automatic routine as outlined below. The 4300 must be in single channel mode and the sensor connected to a calibrator, either the one in the 4300 or an external calibrator at 0 or -20 dBm. The sensor must have a type entered (5 digit number) and it must be assigned to the channel to be calibrated. The automatic routine is as follows:

1. Zero's the channel.

2. Determines if a Programmable 30 MHz Calibrator is installed.

3. Determines if the sensor is connected to a fixed 0 dbm source, a -20 dBm source, or the programmable calibrator.

4. Based on 2 and 3 above, the 4300 will execute an automatic or a fixed cal as described below. The ENTER key must also be pressed as prompted by the display.

NOTE

When a 75 ohm sensor is used with the calibrator, compensation must be made for the mismatch. See paragraph 3-9, "75 OHM SENSOR CALIBRATION".

3-53. Autocal: This routine steps the programmable calibrator through the entire sensor range in 1 to 6 dB steps (sensor and range dependent) up to +20 dBm. Each point is calibrated, accounting for sensor and input channel non-linearities, input channel DC gain error, and offsets. The routine displays error conditions as appropriate. If a particular point will not calibrate, the routine exits, showing the power level in dBm which the calibrator failed. This routine serves as an excellent check of the overall measurement path. Zeroing the channel before executing an autocalibration is not necessary, although power should be removed from the sensor for 30 seconds before autocalibrating. The autocal routine takes about 100 seconds.

3-54. Fixed Cal: This routine calibrates at 0 or -20 dBm (determined automatically). Millimeter wave sensors are generally calibrated at -20 dBm. The channel should be zeroed first. The fixed calibration can be applied on top of the autocal calibration. For example, the autocalibration cycle can be executed to linearize the sensor, and then an overall correction can be applied by connecting the sensor to a fixed calibrator at 0 dBm. This may be useful when it is desired to have the traceability of several instruments (not all 4300's) to a given 0 dBm source.

Operation	Press	Display Shows
Automatically calibrates a sensor and channel	SHIFT AUTOCAL ENTER	Autocal messages

3-55. CALIBRATOR LEVEL Key. Displays the current level setting of the 30 MHz calibrator even if it is turned off. The range of values entered is between -60 and +20 dBm in 1 dB steps. When a value is entered into cal level the new value is compared against the cal limit. If the new value is greater than the cal limit, an error is generated. The output is activated when ENTER is pressed.

Operation	Press	Display Shows
Sets the calibrator output level	LEVEL	Present Cal level in dBm
	Desired output level	Desired output level in dBm
	ENTER	

3-56. RANGE SET Key. Prompts the user for the range (0-6 for diode sensors, 0-3 for thermal sensors), and applies it to all displayed channels. Refer to Note 1 above. Activates the hold range mode.

Operation	Press	Display Shows
Sets a range	SHIFT, RANGE SET n (0-6) ENTER	 RANGE n, HLD

3-57. RANGE HOLD Key. Locks each channel that is displayed into its present range. Ranges are roughly in 10 dB steps and are sensor type dependent. Disabled by going to autorange mode. Refer to Note 1 above.

Operation	Press	Display Shows
Hold a given range	HOLD	Adds HLD to presently displayed range number

3-58. RANGE AUTO Key. Puts each channel that is displayed in autorange mode.

Operation	Press	Display Shows
Auto ranges the input channels	AUTO	Range

3-59. INSTR STORE Key. Prompts the user for a number 1-9 for which to store the full panel setup. A given SETUP contains: mode (single, multi or summation channel), operating frequency, calibrator level, recorder output scaling, measurement units (dBm, Watts, dBr) dB reference, HI and LO limits, range mode (hold or auto), range (in hold mode), the summation equation, duty cycle (if applicable), dB cal factor, peak hold enable, the calibrator high limit, trigger delay, bar graph enable, trigger mode, IEEE-488 bus talk mode, and the channel whose chart recorder output is assigned to summation result. The sensor data is in a separate memory sector and is not affected by instrument store or recall functions.

Operation	Press	Display Shows
Store a panel setup	SHIFT, STORE	Storage number (1-9)
	Storage number (1-9)	
	ENTER	

3-60. INSTR RECALL Key. Recalls one of nine previously stored panel setups, or, when state 0 is called up, recalls a default state. The calibrator always comes up in the off condition. Refer to the INSTR STORE key. The default state is shown below:

3-61. Recall 0 Conditions

Single channel, channel 1
Auto range
Calibrator Off, level at -60 dBm, max limit at +10 dBm
dBm mode
Duty cycle = 100% (disabled)
Peak mode disabled
Frequency = 30 MHz
dB cal factor = 0 dB
dB reference = 0 dBm
High limit = +99.99 dBm
Low limit = -99.99 dBm
Chart recorder scaling from -60 dBm to +20 dBm
Default filters are as shown:

Range	Universal Channels	Thermal Channels
0	2.8 sec	4.8 sec
1	0.8 sec	1.8 sec
2	0.3 sec	0.6 sec
3	.06 sec	0.3 sec
4	.06 sec	-
5	.06 sec	-
6	.06 sec	-

Channel summation (ratio) set for Ch1-Ch2
Free run (untriggered) mode
Trigger Delay = 130 msec
Bar Graph disabled
IEEE-488 Talk Mode 0

Operation	Press	Display Shows
Recall a previously stored panel setup	SHIFT, RECALL	Recall number
	n (1-9)	
	ENTER	
Recall the default panel setup	SHIFT, RECALL	Recall state 0
	0	
	ENTER	

3-62. SRQ Key. Refer to "REMOTE (GPIB) OPERATION".

3-100. REMOTE (GPIB) OPERATION.

3-101. Introduction. The remote operation of the 4300 is accomplished through an IEEE-488-1978 interface. The IEEE-488 is a hardware standard which describes the communication and handshaking across the 8 bit parallel bus between a controller and up to 15 instruments.

3-102. The 4300 interfaces to the bus using a 9914A bus interface IC and tristate buffers. No DMA operations are supported. The table below lists the capabilities of the 4300.

		Capability
C0	NO CONTROLLER	
SH1	SOURCE HANDSHAKE	Complete Capability
AH1	ACCEPTOR HANDSHAKE	Complete Capability
RL1	REMOTE LOCAL	Complete Capability
DC1	DEVICE CLEAR	Complete Capability
DT1	DEVICE TRIGGER	Complete Capability
SR1	SERVICE REQUEST	Complete Capability
PP0	PARALLEL POLL	No Capability
TE0	EXTENDED TALKER	No Capability
T6	BASIC TALKER	Complete Capability, except for talker only
LE0	EXTENDED LISTENER	No Capability
L4	BASIC LISTENER	Complete Capability, except for listener only

3-103. Local Operation. This is the front panel operation of the instrument. The local mode is the power on condition of the bus and the remote condition becomes active only when the instrument is remote addressed by the controller. Once in the remote mode, there are three ways to return the instrument to local mode: 1) The controller issues a GTL command (go to local); 2) Power is removed from the instrument; and 3) The operator presses the ESCAPE key (actually this is an ESCAPE / LOCAL key). This third method is disabled by issuing a local lockout command (LLO). The instrument will still talk and listen when addressed, even if it's not in the remote mode.

3-104. Remote Operation. When in remote mode all key closures are ignored except the ESCAPE (LOCAL) key (disabled by LLO). When in the remote mode the message REM appears in the display in the lower right corner.

3-105. Setting The Bus Address. The IEEE-488 listen/talk address (MLTA), can be set or altered only from the panel of the instrument by use of the ADRS key. Refer to the "ADRS" key in Section 3.

3-106. Terminating Characters. To inform the instrument that a complete message has been sent, the last character must be followed by a termination. The termination can be done either by asserting the EOI line on the bus or by sending an in-line terminating character, or both. The terminating character should be CR, LF or CRLF. The selection of the terminating characters that are recognized is done by bit switch settings. For information on bit switch settings refer to Table 6-202 and Figure 6-201.

3-107. Bit Switch Settings (Rear Panel). The Bit switch on the rear panel sets the 4300 up to accept line feeds or carriage returns as terminators, and sets miscellaneous functions. Refer to Table 6-202. The bus address is not controlled by this switch.

3-108. Listen Operation. The instrument may be addressed as a listener without regard for remote or local mode. When the listener state is set by the controller, the instrument will receive bytes over the bus and place them into its input buffer, and the LSN message will appear in the lower right hand corner of the display. For listen operation the input buffer is 512 characters long. Only one message can be put into the input buffer at a time. A second can not be sent until the instrument is done processing the previous message.

3-109. Talk Operation. When the 4300 is requested to talk, it will respond according to how it has been set up. The setup is either through talk modes or Talk Array commands. The talk modes are associated with making measurements; the Talk Array commands are associated with downloading calibration data and instrument states. Refer to BUS Only Commands for setting up the talk mode.

3-110. Only one instrument at a time can be addressed to talk; while many instruments can be addressed to listen simultaneously. When in the talk mode, the 4300 displays the TLK message in the lower right corner of the display. The format for each talk message is different and is explained individually in the sections that follow.

3-111. IEEE-488 Commands Supported. The 4300 supports the following standard IEEE-488 commands:

1. **Interface Clear Command.** The interface clear (IFC) command forces all devices on the bus to clear their interfaces, returns the instrument to local and returns the bus (not the instrument) to an initialized state, clearing the error conditions. This command can only be issued by the controller in charge. The 4300 responds by clearing the interface and executing the equivalent of the Escape command.

2. **Device Clear.** For this instrument, the device clear (DCL) command operates the same way as the IFC command, described above.

3. **Group Execute Trigger.** The Group Execute Trigger (GET) command allows the controller to issue a trigger to all instruments on the bus simultaneously. The GET command is most useful when the instrument is in a triggered measurement mode. The actual operation executed by the 4300 is the same as the software trigger command; refer to the SPECIAL function key and the section on triggered operation (Sections 3 and 4). When in free run mode the instrument will save the current reading at the time of the GET command and return it at the time of the next "talk measure" mode. This is not the

TABLE 3-7. LISTEN PARAMETER COMMANDS

KEY COMMANDS		
MNEMONIC	PARAMETER NUMBER	REFERENCE
SETCH	1	"
SETREF	2	"
FREQ	3	"
DBCF	4	"
ASSIGN	5	"
LOLIM	8	"
HILIM	9	"
SET	11	See the key descriptions in Section 3.
RECALL	12	"
STORE	13	"
LIMIT	14	"
LEVEL	15	"
DTYCY	16	"
S/N	21	"
FILTER	20	"

NON-KEY COMMANDS		
MNEMONIC	PARAMETER NUMBER	CORRESPONDS TO
TRDELAY	17	SPECIAL 1, 5 (See SPECIAL key)
RECSUM	32	SPECIAL 2, 2 (See SPECIAL key)
RECTOP	33	SPECIAL 2, 1 (See SPECIAL key)
RECBOT	34	SPECIAL 2, 0 (See SPECIAL key)
RECLEVEL	35	SPECIAL 2, 8 (See SPECIAL key)
TALKMODE (or TM)	22	No correspondence; sets talk mode; See "Bus Only Commands"
SRQMASK	23	No correspondence; sets SRQ mask; See "Bus Only Commands"

same as a triggered operation; this reading is based on the measurement history before the GET command. This is in essence a bus latch; the input channels are not triggered or affected.

4. **SRQ.** The Service Request allows an instrument to inform the controller that some special event has occurred. The instrument then expects the controller to perform a serial poll to find out what event has occurred. The events that can be selected to generate service requests are instrument error, measurement error, measurement is ready, zeroing is completed and requesting service from the front panel. Each of these options can be individual enabled or disabled with the 4300 SRQ mask. The default settings for the mask are with all SRQ's disabled. They can only be enabled by setting the appropriate bits high in the SRQ mask over the bus with the SRQMASK command. The bit map for enabling SRQ's is shown in Table 3-12. See Section 3-142, "SRQMASK".

5. **Serial Poll.** The Serial Poll (SP) command on the bus allows the controller to check the SRQ status byte of each instrument and determine which instrument is requesting service. The byte returned by the 4300 is made up of multiple bits representing different status and error conditions. These conditions are individually maskable, as shown in Table 3-12.

6. **Parallel Poll.** The Parallel Poll (PP) command is not supported.

3-112. Number Formatting. Number formatting is shown for each of the commands in the sections that follow, but general rules are shown below:

1. Fixed or floating formats are accepted.

2. The optional + or – may precede the mantissa and/or the exponent.

3. An optional decimal point may appear at any position within the mantissa. A decimal point in the exponent is ignored.

TABLE 3-8. LISTEN ACTION COMMANDS

KEY COMMANDS MNEMONIC	REFERENCE
ESCAPE (or ESC)	"
DBR (or dBr)	"
DBM (or dBm)	"
WATTS	"
LOAD	"
ZERO	"
ON (ON and OFF represent	"
OFF the calibrator ON/OFF key)	"
AUTOCAL	"
HOLD	See the key descriptions in Section 3.
AUTO	"
DSBL	"
SUMENA	"
CHAN	"
MULTI	"
PKHLD	"
PKOFF	"

NON-KEY COMMANDS	CORRESPONDS TO
DSTEST	TEST 2 (see TEST key)
ACCAL	SPECIAL 5 (see SPECIAL key)
RECLIM	SPECIAL 2, 5 (See SPECIAL key)
RECOFF	SPECIAL 2, 3 (See SPECIAL key)
RECRAW	SPECIAL 2, 6 (See SPECIAL key)
RECZERO	SPECIAL 2, 4 (See SPECIAL key)
RECMEAS	SPECIAL 2, 7 (See SPECIAL key)
FREERUN	SPECIAL 1, 0 (See SPECIAL key)
FILTERED	SPECIAL 1, 1 (See SPECIAL key)
SETTLED	SPECIAL 1, 2 (See SPECIAL key)
TRFILTER	SPECIAL 1, 3 (See SPECIAL key)
TRSETTLE	SPECIAL 1, 4 (See SPECIAL key)
BATTEST	TEST 7 (see TEST key)
GRAPHON	SPECIAL 7 (See SPECIAL key)
GRAPHOFF	SPECIAL 7 (See SPECIAL key)
KEYTEST	TEST 1 (see TEST key)
MEMTEST	TEST 3 (see TEST key)
RAWCHAN	SPECIAL 8 (See SPECIAL key)
TRIGGER (or TR)	SPECIAL 9 (See SPECIAL key)
DSON	No correspondence; turns display on; See "Bus Only Commands"
DSOFF	No correspondence; turns display off; See "Bus Only Commands"

4. The optional "E" for exponent may be upper or lower case.

5. All ASCII characters below and including ";"(3Bh) are considered command delimiters. The ASCII characters " " (20h), "," (2Ch), ";" (3Bh), and ":" (3Ah) are considered numeric delimiters.

3-113. String Format. The string formatting is as follows:

1. The programming sequence is in natural order, that is, a function mnemonic is sent first followed by the argument value (parameter), if appropriate.

2. The data strings sent to the instrument are case sensitive. This means lower case and upper case are not the same.

3. Spurious numbers occurring in the Listen string are ignored.

4. All block modes have their data arrays or ASCII strings enclosed by square brackets [ ] for error checking. Some block commands require numeric data outside of the block. This number must precede the first bracket ([).

3-114. Listen Parameter Commands. Listen Parameter Commands are listed in Table 3-7 and are commands received by the instrument that expect one numerical value to follow, for setting a particular operating condition. Except as noted in the table, these commands correspond to specific front panel commands. "Key" commands correspond to single keystrokes; "non-key" commands are submodes or menu types of data entry.

3-115. The numeric value (parameter) can be sent in the next listen string if the listen parameter command was the last value of the previous string. If for any reason a command is sent without a parameter following it, the ESCAPE command can be used to clear the active command, or a new command can be used. The parameter number listed in the table is the number returned when the Talk Parameter mode is exercised (Talk Mode 6).

3-116. Listen Action Commands. Listen Action Commands are listed in Table 3-8 and initiate an action without any parameters being sent. As in the Listen Parameter Commands, the "key" and "non-key" commands correspond to single keystrokes or menu types of data entry, as listed in the table.

3-117. Listen Array Commands. Listen Array Commands transfer arrays of data (more than one parameter) to the instrument, such as sensor data or DC calibration data, as listed in Table 3-9. The data in the arrays is enclosed within square brackets "[]" for error checking and is separated by valid delimiters. The actual amount of data depends on the specific command being used. Listen Array Commands are only operable over the bus and have no application from the front panel.

TABLE 3-9. LISTEN ARRAY COMMANDS

COMMAND	REFER TO
CHANSUM	"
DATAIN	"
DCIN	"Bus Only Functions"
FREQIN	"
LEARN	"
MESSAGE	"

3-118. Talk Array Commands. Talk Array Commands are listed in Table 3-10 and build a talk string in the talk buffer for transmission. Not for general purpose measurement (use the talk modes for that), they are used for transmitting arrays of data (more than one parameter) such as sensor data and DC calibration data. The buffer contents are dispersed at the time of the next instrument talk request. These commands automatically change the talk mode to seven or eight, depending on the data type, then reset the 4300 to talk mode 0. This is the only time that the instrument uses the talk buffer or talk string modes (talk modes 7 and 8). The Talk Array commands are operable only over the bus.

TABLE 3-10. TALK ARRAY COMMANDS

COMMAND	REFER TO
DATAOUT	"
DCOUT	"
FREQOUT	"Bus Only Commands"
TEACH	"

3-119. Talk Modes. When the 4300 is requested to talk, it will respond according to how it has been set up. The setup is either through Talk Array commands or Talk modes. The Talk modes are associated with making measurements; the Talk Array commands are associated with downloading calibration data and instrument states. The Talk modes are described below.

The 4300 supports nine talk modes of operation, as listed in Table 3-11. Once the Talk mode is set, the controller need only tell the 4300 to talk and it will respond according to the Talk mode.

Modes 0 through 6 are directly setable by the use of the TALKMODE (or TM) command. For these modes the instrument will remain in the selected mode until the Talk mode is changed or until a Talk Array command is received. Talk modes 7 and 8 are temporary Talk modes that are automatically enabled in response to a Talk Array command (these modes can't be set by the controller directly). These temporary Talk modes are disabled (talk mode returned to zero) when the Talk Array operation is complete.

The current Talk mode is saved in non-volatile memory and will remain in that mode when the power of the instrument is cycled on and off. The default condition for Talk mode is zero (set with the RECALL 0 operation or an instrument initialization from the rear panel Bit switch). The Talk modes are described in sections following the table.

TABLE 3-11. TALKMODES

TALKMODE	DESCRIPTION
0	Talk Measurement Floating Point
1	Talk Measurement with Units
2	Talk Error
3	Talk Error with Messages
4	Talk Channel Status
5	Talk Instrument Status
6	Talk Parameter
7	Talk Array
8	Talk String

3-120. TALKMODE 0 (Talk Measurement Floating Point):

1. **Single Channel and Summation Mode Format:** #1, #2

where:

#1 is the error flag (1 = error, data invalid);

#2 is the measurement in floating point notation, in the units selected (dBm, dBr, or nanowatts). In watts mode the units are fixed in nW.

Examples:
0,0.00E00 — No error, power is 0.00 dBm.
1,-75.00E00 — Under range error at -75.00 dBm.
0,98.9E00 — No error, power is 98,900 milliwatts.
1,50.85E00 — High Limit exceeded at 50.85 dBr.

2. **Multichannel Mode Format:** #1,#2,#3,#4,#5,#6,#7

where:

#1 is the error flag (1 = error, data invalid);

#2 through #7 are the measurements in floating point notation, in the units selected (dBm, dBr, or nanowatts. In watts mode the units are fixed in nW.

In multi-channel mode a special case exists when there are less than six channels installed. Strictly speaking, the instrument should error out, since measurements on six channels is invalid. However, for this special case no error is generated, because if it did every unit without six channels would always generate an error. Instead the instrument only returns measurement errors for those channels installed.

Example:

0,0.00E00,1.00E06,-20.00E00,-75.00E00 — All readings are correct. Channel 2 has the units set to watts and channels 1,3,4 are set to dBm. Only 4 channels are installed in the unit, so only 4 numbers are returned.

3-121. TALKMODE 1 (Talk Measurement with Units).

1. **Single Channel and Summation Mode Format:** #1, $1

where:

#1 is the error flag (1 = error);

$1 is the measurement. The format is fixed point followed immediately by a three character string that indicates the units of the measurement. The possible units are "dBm", "dBr", "dB", "nW", "uW", "mW", "W", "%", and " ". The "%" and "dB" are for when the instrument is in the summation mode. The " " indicates the value is raw data (see SPECIAL function 8).

If need be the string can be parsed externally into a number and a three character message.

Examples:
0,0.00dBm — No error at 0.00 dBm.
1,-75.00dBm — Under range error at -75.00 dBm.
0,98.9uW — No error at 98.9 microwatts.
1,50.85dBr — High Limit exceeded at 50.85 dBr.

2. **Multichannel Mode Format:** #1,$1,$2,$3,$4,$5,$6

where:

#1 is the error flag (1 = error);

$1 through $6 are the measurements. The format is fixed point followed immediately by a three character string that indicates the units of the measurement. The possible units are "dBm", "dBr", "dB", "nW", "uW", "mW", "W", "%", and " ". The "%" and "dB" are for when the instrument is in the summation mode. The " " indicates the value is raw data (refer to SPECIAL function 8. Only installed channels return measurements.

If need be the string can be parsed externally into a number and a three character message.

Example:

0,0.00dBm,1.00mW,-20.00dBm,-75.00dBm — All readings are correct. Channel 2 has the units set to watts and channels 1,3,4 are set to dBm.

3-122. TALKMODE 2 (Talk Error).

Format: #1,#2,#3

where:

#1 is the instrument error number, from 0 to 70. A "0" indicates no error. Refer to Table 3-13 for the error messages.

#2 is the measurement error, from 0 to 70. A "0" indicates no error. Refer to Table 3-13 for the error messages.

#3 is the channel(s) reporting errors, from 1 to 7 sequential digits. Each digit represents a channel (1-6), and a 0 represents the control board or main frame. A channel will report on error if an error has occurred since the error condition was cleared. Errors are cleared by the execution of a Talk Error operation or an ESCAPE command. The individual channel numbers can be extracted by simply dividing the number by ten until the remainder is zero.

The execution of this Talk mode automatically clears the instrument error after it is reported. If more than one error occurs the instrument will indicate the first one that occurred.

Examples:

0,0,0 — No error is reported.
0,3,2 — Channel 2 is underrange.
0,14,123456 — No channels are installed in the instrument for multi-channel mode measurements.
24,0,0 — Frequency entry is out of range for sensor data table.
1,0,0 — Number entry is out of range for selected function.
1,3,2 — Number entry is out of range and channel 2 is underrange.

3-123. TALKMODE 3 (Talk Error with Message).

Format: #1,#2,#3,$1

where:

#1 is the instrument error number, from 0 to 70. A "0" indicates no error. Refer to Table 3-13 for the error messages.

#2 is the measurement error, from 0 to 70. A "0" indicates no error. Refer to Table 3-13 for the error messages.

#3 is the channel(s) reporting errors, from 1 to 7 sequential digits. Each digit represents a channel (1-6), and a 0 represents the control board or main frame. A channel will report an error if an error has occurred since the error condition was cleared. Errors are cleared by the execution of a Talk Error operation or an ESCAPE command. The individual channel numbers can be extracted by simply dividing the number by ten until the remainder is zero.

$1 is the message portion, consisting of 15 characters. This message is exactly the same as the error message that appears in the upper right hand corner of the front panel display in local operation. If an instrument error and a measurement error are both reported the message will describe the instrument error because it is considered potentially more important.

The execution of this talk mode automatically clears the instrument error after it is reported. If more than one error occurs the instrument will indicate the first one that occurred.

Examples:

0,0,0, — No error is active.
0,3,2,Err Under RANGE — Channel 2 is underrange.
0,14,123456,No Channel Card — No channels are installed in the instrument for multichannel mode.
24,0,0,Out of Freq Rng — Frequency entry is out of range for sensor table. Number entry is out of range for selected function.
1,0,0,Err Range of # — Number entry is out of range for selected function.
1,3,2,Err Range of # — Number entry is out of range and channel 2 is underrange.

3-124. TALKMODE 4 (Talk Channel Status).

Format: #1,#2,#3,#4,#5,#6,#7

where:

#1 is the selected channel to which the following data pertains to.

#2 is the channel status or type, according to the table below:

0	No Channel Installed.
1	The channel is a universal type.
2	The channel is a Thermal type.
13	The channel has a battery error.
14	The channel card is reporting an error.
15	The channel has a memory error.
16	The channel slot is filled with a special trigger option.

#3 is the measurement units that the channel is set to, according to the following table:

0	Power in Watts, mW, μW, or nW.
1	Power in dBm.
2	Power in dBr.
10	Reading is the raw value.

#4 indicates the trigger mode of operation.

0	Free Run
1	Free Run Filtered.
2	Free Run Settled.
3	Trigger Filtered.
4	Trigger Settled.

#5 indicates if the channel has the duty cycle enabled (1 = enabled).

#6 indicates if the channel is currently performing a zero operation, according to the following table:

0 Channel not zeroing.
1 Channel is decaying.
2 Channel is checking if zero can be done.
3 Channel is settling.
4 Channel is performing zeroing operation.

#7 indicates the software revision number of the channel EPROM.

NOTE

The mode of operation of the instrument (single channel, multi-channel or summation channel) does not affect the operation of this talk mode.

Examples:

1,1,1,0,0,0,1.00 — Channel 1 is a universal card with its units in dBm, in free run mode with no duty cycle correction applied. The channel is not presently being zeroed. The software level of the channel card is 1.00.

6,1,2,2,1,3,1.00 — Channel 6 is a universal card with its units in dBr, in free run settled mode with a duty correction applied. The channel is presently being zeroed. The software level of the channel card is 1.00.

3-125. TALKMODE 5 (Talk Instrument Status).

Format: #1,#2,$1,$2

where:

#1 is the current operating mode, according to the table below:

0 Single channel mode.
1 Multi-channel mode.
2 Summation mode.

#2 is the calibrator activity indicator (30 MHz programmable calibrator only; 1 = output is enabled and 0 = output disabled).

$1 is the control board software version.

$2 is the programmable calibrator calibration date. If not installed, a 0/00 is returned.

Examples:

0,0,1.00,0/0 — The instrument is in single channel mode with the programmable calibrator turned off. The software version is 1.00 and the programmable calibrator is not installed in the instrument.

2,1,1.00,1/87 — The instrument is in the Summation mode with the calibrator output on. The software version is 1.00 and it was last calibrated in January 1987.

3-126. TALKMODE 6 (Talk Parameter).

1. **Format:** #1,#2

where:

#1 is the active parameter number 0 = no parameter selected).

#2 is the active parameter value, for example "frequency". The units are defaulted.

2. This command returns two numbers which describe the current "opened" (or selected) parameter in the instrument and its value. For example, the frequency that a channel is set to can be read over the bus. To read a parameter, it must be "opened" first as described below. A parameter in the 4300 is defined to be a front panel or bus command that allows or requires a numerical value to be entered into it. The parameters are listed in Table 3-2, and the parameter numbers are listed in Table 3-7.

3. The data sent over the bus is the same as the data displayed in the entry field in the upper right corner of the display whenever a parameter is selected. This information is generally retrieved from the instrument in the single channel mode, because the parameters are generally different for each channel. In multi-channel and summation modes, if the parameters are different, (for example if the channels have different digital filter lengths), no parameter will be returned on the bus. The Talk Parameter command will act as if no parameter was open. Incidentally, if in local mode, the display would be blank in this case.

4. To use this talk mode, the instrument is first placed in Talk Mode 6, then a parameter is opened (made active) by pressing the appropriate key or by sending the bus command. No numeric value should follow and the Escape command should not be used. Then while the parameter is active a talk command is issued to the instrument and the data for that parameter will be sent out on the bus. To deactivate a parameter simply enter a number, send another command or issue the Escape command.

Examples:

0,0 — No parameter is active and the second value should be ignored.
2,-10,00 — The set dB reference (parameter number 2) is currently set to -10.00 dBm.
5,1 — Sensor 1 is assigned to the current channel.
3,1.23 — The frequency is set to 1.23 Gigahertz.

3-127. TALKMODE 7 (Talk Array).

1. **Format:** Each of the different Talk Array commands has a different format; refer to the applicable section in "Bus Only Commands".

2. Not directly settable by the controller, this Talk mode builds a data string in the talk buffer for a one time transmission. It is used to send an array of numerical data or a string of character data, in the "teach" modes (downloading sensor and/or calibration data). This mode is set internally automatically by the execution of one of the Talk Array commands. Once executed this mode is automatically cleared to talk mode 0 as the default condition.

3-128. TALKMODE 8 (Talk String).

1. **Format:** Each of the different Talk String commands has a different format; refer to the applicable section in "Bus Only Commands."

2. Not directly settable by the controller, this command is set automatically by use of the TEACH command. This command is a special case to allow the transmission of data that is longer than one buffer. This command is only used by the TEACH command. This mode is always cleared to Talk mode 0 when the teach operation is completed.

3-129. IEEE-488 BUS ONLY COMMANDS.

This section covers commands that are available only under remote operation on the bus.

3-130. TALKMODE. The TALKMODE command is used to change to a selected Talk mode. The range of data for this command is from 0 to 6. Talk mode 7 and 8 can only be set indirectly by the execution of a Talk Array Command. This command can be abbreviated as TM for simplicity. This command is classified as a Listen Parameter command.

Example:

TALKMODE 0 — Set talk mode 0 (Talk Measure).
TM 3 — Set talk mode 3 (Talk Error with Message).

3-131. DATAIN. Used in conjunction with the DATAOUT command, this command is used to send a portion of the sensor calibration data to the 4300, in the form of an array of numeric data. In this way sensor data can be transferred from one instrument to another, or stored on a disk.

1. The data is the 14 point linearity data (AC reference frequency linearity data) for a selected sensor and is placed in the sensor data bank (independent of channels). This command corresponds to a subsection of the Sensor Data Entry command which is available from the keyboard. This command complements the DATAOUT command over the bus and the DATAOUT command would normally be the source of the data string for this command. This command is classified as a Listen Array Command.

2. In addition to the 14 point data, each sensor has high frequency calibration data, which is loaded with the FREQIN command.

3. **Format:** DATAIN [sensor type, sensor serial number, U0,U1,U2,U3,U4,U5,U6,D0,D1,D2,D3,D4,D5,D6].

where:

sensor type is a number in the form 51XXX. Sensors must be resident in the instrument firmware. To access the resident types, use the sensor type menu within the Sensor Data Entry key from the front panel.

sensor serial number is from 1 to 999999.

U0 through U6 are the Upscale gain factors (1000 to 10000, nominally 5000).

D0 through D6 are the downscale factors (-200 to +200).

4. Each numeric value must be separated by a valid delimiter. The square brackets need to have at least one space on each side of them for correct operation, except the trailing one if it is the last character to be sent.

Example:

DATAIN [5013,12345,5012,5003,5032,5013,4995,5005,4891,-20,-21,2,-3,-14,15,6]

3-132. DATAOUT. Used in conjunction with the DATAIN command, this command is used to send sensor calibration data out to the controller. See the DATAIN command for descriptions of the general use of these commands. Sensor data also consists of high frequency calibration data, which is handled with the FREQOUT command.

1. When executed, this command instructs the instrument to build an array of numeric data in the talk buffer for transmission by the next talk request. The array consist of numeric data representing the 14 point linearity data (AC calibration data) for a selected sensor. This command corresponds to a subsection of the Sensor Entry cmmand which is available from the keyboard. This command complements the DATAIN command over the bus and the DATAIN command would normally be the destination of the data string of this command. The DATAOUT command is classified as a Talk Array Command.

2. The Talk mode is temporarily set to 7 (talk array) when this command is executed. After this talk command has been executed the Talk mode is reset to 0 (talk measure). An Escape command will also reset the Talk mode.

3. **Format:** To the instrument in a listen string: DATAOUT.

From the instrument in the next talk string: [sensor type, sensor serial number, U0,U1,U2,U3,U4,U5,U6,D0,D1,D2,D3,D4,D5,D6]

where:

(See the DATAIN command for the format descriptions.)

4. Each numeric value must be separated by a valid delimiter. The square brackets need to have at least one space on each side of them for correct operation, except the trailing one if it is the last character to be sent.

Example:

To the instrument in a listen string: DATAOUT.
From the instrument in the next talk string: [51013,12345,5023,5001,5012,5010,4997,5005,5003, 10,13,-2,-23,14,-15,6]

3-133. FREQIN. Used in conjunction with the FREQOUT command. This command is used to send sensor high frequency calibration data to the 4300 for a selected sensor in the form of an array. In this way sensor data can be transferred from one instrument to another, or stored on a disk. In addition to the high frequency calibration data, there is 14 point calibration data, which is loaded with the DATAIN command.

1. The data is for a selector sensor and is placed in the sensor data bank (independent of channels). This command corresponds to a subsection of the Sensor Data Entry command which is available from the keyboard. This command complements the FREQOUT command over the bus and the FREQOUT command would normally be the source of the data string for this command. This command is classified as a Listen Array Command. The data is loaded in blocks of 15 points.

2. **Format:** FREQIN n [F1,DBCF1,F2,dBCF2. . . . . F15,DBCF15]

where:

n is the pointer, see text below, from 1 to 80;

F1 is the first frequency of this group, from 0.00 to 110 GHz in .01 GHz increments;

DBCF1 is the first dB Cal Factor for this group, from -3.00 to 3.00 dB in .01 dB increments;

3. Each numeric value must be separated by a valid delimiter. The square brackets need to have at least one space on each side of them for correct operation, except the trailing one if it is the last character to be sent.

4. The total number of frequency points is limited to 80 for sensors 1 through 6, and 35 for sensors 7 through 20. The pointer is the beginning location for the frequency/dB Cal factor pairs. The pointer must not exceed 65 if the group contains 15 points, for a total of 80 points. Likewise, the pointer must not exceed 20 for sensors 7 through 20, if the frequency group has 15 points.

5. Frequency Cal points must be in numerical order of frequency. Generally, the first point is at 0 GHz or .01 GHz, with a Cal Factor of 0, so that in the operating mode, frequencies down to .01 GHz can be entered.

6. Examples:

FREQIN 1 [0.00,0.00,1.00,-0.05,2.00,-0.07,3.00, 0.10,4.00,-0.06,5.00,-0.05,6.00,0.00,7.00,0.13,8.00, 0.42,9.00,0.34,10.00,0.00,11.00,0.15,12.00,0.32,13.00, 0.25,14.00,0.43]

FREQIN 16 [16.00,0.00,17.00,-0.50,18.00,-0.12, 19.00,-0.10,20.00,0.06,20.05,0.05,20.10,0.04,20.15, 0.03,20.20,0.04,21.00,0.04,25.00,0.05]

3-134. FREQOUT. Used in conjunction with the FREQIN command, this command is used to send sensor high frequency calibration data out to the controller. See the FREQIN command for descriptions of the general use of these commands. Data points are loaded in blocks of 15.

1. When executed, this command instructs the instrument to build an array of numeric data in the talk buffer for transmission by the next talk request. The array consists of numeric data representing the dB cal factor information for a selected sensor. This command corresponds to a subsection of the Sensor Entry command which is available from the keyboard. The FREQOUT command is classified as a Talk Array Command.

2. The Talk mode is temporarily set to 7 (talk array) when this command is executed. After the talk command has been executed the Talk mode is reset to 0 (talk measure). An Escape command will also reset the Talk mode.

3. **Format:** To the instrument in a listen string: FREQOUT n

From the instrument in the next talk string. [F1, DBCF1,F2,dBCF2, ... F15,dBCF15]

where:

n is the pointer, see text, from 1 to 80;

F1 is the first frequency of this group, from 0.00 to 110 GHz in .01 GHz increments;

DBCF1 is the first dB Cal Factor for this group, from -3.00 to 3.00 dB in .01 dB increments; etc.

4. Each numeric value must be separated by a valid delimiter. The square brackets need to have at least one space on each side of them for correct operation, except the trailing one if it is the last character to be sent.

5. Refer to the FREQIN command for limitations on the pointer and starting frequencies, and for general use of this command.

6. Example:

Command sent to the instrument: FREQOUT 1
The numeric array built into the talk buffer: [0.00, 0.00,1.00,-0.05,2.00,-0.07,3.00,-0.10,4.00,-0.06,5.00, -0.05,6.00,0.00,7.00,0.13,8.0,0.42,9.00,0.34,10.00, 0.00,11.00,0.15,12.00,0.32,13.00,0.25,14.00,0.43]

3-135. DCIN. Used in conjunction with the DCOUT command, this command is used to send DC calibration data to the instrument for a selected input channel, in the form of an array. In this way, calibration can be done in an automatic test station. Also, calibration data can be retrieved from an already calibrated unit and stored on a disk.

1. The data is a gain constant for each range, and an ADZERO term which is a downscale adjustment. It is stored on each channel board in nonvolatile RAM.

2. This command corresponds to the SPECIAL 3 command which is available from the keyboard. This command complements the DCOUT command. This command is classified as a Listen Array Command.

3. **Format:** DCIN [G0,G1,G2,G3,G4,G5,G6,ADZERO]

where:

G0 through G6 are the gain constants for ranges 0 through 6, ranging from 4000 to 7500 (nominally 5000);

ADZERO is the downscale adjustment, ranging from -15 to 15, nominally 0.

4. Each numeric value must be separated by a valid delimiter. The square brackets need to have at least one space on each side of them for correct operation, except the trailing ne if it is the last charcter to be sent.

5. Example:

DCIN [5000,5001,5002,5003,5004,5005,5006,-1]

3-136. DCOUT. Used in conjunction with the DCIN command, this command is used to load DC calibration data out to a controller for later re-entry into the instrument.

1. When executed, this command instructs the instrument to build an array of numeric data in the talk buffer for transmission by the next talk request. The array consists of a gain constant for each range, and an ADZERO term which is a downscale adjustment. It is stored on each channel board in nonvolatile RAM.

2. This command corresponds to the Special 3 function available from the keyboard. The DCOUT command is classified as a Talk Array Command.

3. The Talk mode is temporarily set to 7 (Talk array) when this command is executed. After the talk command has been executed the Talk mode is reset to 0 (talk measure). An Escape command will also reset the Talk mode.

4. **Format:** To the instrument as a listen string: DCOUT

From the instrument in the next talk string: [G0,G1, G2,G3,G4,G5,G6,ADZERO]

where:

G0 through G6 are the gain constants for ranges 0 through 6, ranging from 4000 to 7500 (nominally 5000, except range 6 which is 6635);

ADZERO is the downscale adjustment, ranging from -15 to 15, nominally 0.

5. Each numeric value must be separated by a valid delimiter. The square brackets need to have at least one space on each side of them for correct operation, except the trailing one if it is the last character to be sent.

6. Example:

To the instrument in a listen string: DCOUT
From the instrument in the next talk string: [5000, 4889,5002,5029,5034,4990,6645,-1]

3-137. DSOFF. This command is classified as a Listen Action Command. Its functions are 1) to blank the front panel display, for secure ATE applications, 2) to allow user messages to be displayed on the front panel, and 3) to speed up operation by reducing the number of tasks that have to be performed by the 4300. When the display is turned off, the display hardware is still functional but it is not updated for certain types of information. The data that is still displayed are any messages sent to the display by the MESSAGE command and also instrument status (displayed in the lower right of the display). The instrument status includes the IEEE-488 bus status (M for MATE, REM for REMOTE, TLK or LSN for TALK or LISTEN and SRQ for Service Request activity), keyboard shift indicator and programmable calibrator output indicator.

3-138. DSON. This command enables the front panel display, complementing the DSOFF command. This command is classified as a Listen Action Command.

3-139. TEACH. In response to this command the 4300 will send three strings of data that represent a selected instrument setup states. An instrument state contains all operating and channel parameters; see the description of the "RECALL" key for what information is included.

1. Each of the three strings are transmitted as separate talk strings and may be up to 256 charcters long. This command is the complement to the LEARN command and is classified as a Talk Array command. Refer to the LEARN command.

2. **Format:** To the instrument: TEACH n

From the instrument: (data string)

where:

n is the register from 0 to 9 from which the setup is taken from. Register 0 is the one that the instrument operates from (loading a setup from register 0 will output the current operating state).

(data string) is a 4300 generated string of arbitrary format.

3. This command automatically sets the Talk mode to level 8 which is Talk String. This command will transmit three buffers of data and then automatically set the Talk mode to 0. If an ESCAPE command is sent while the data strings are being sent, the Talk mode is set to 0 and the TEACH command sequence is aborted.

4. The teach string is of arbitrary sequence and can only be generated from a 4300, and downloaded to a 4300 with an identical software revision. Caution must be exercised when using this command regarding power line stability, etc., because an error in the string could corrupt calibration data for the sensors and possibly the channel cards.

3-140. LEARN. In response to this command the 4300 will expect three strings of data that represent one of the instrument setup states, to be stored in one of ten registers. Each of these strings are received as a separate listen string and may be up to 256 characters long. This command is the complement to the TEACH command and is classified as a Listen Array command. Refer to the Teach command for general information.

1. **Format:** LEARN n (data array)

where:

n is the register form 0 to 9 to store the setup in. Register 0 is the one that the instrument operates from (loading a setup into register 0 will cause the instrument to work with that setup immediately).

(data array) is a 4300 generated string of arbitrary format.

2. The learn string is of arbitrary sequence and can only be generated from a 4300 with an identical software revision.

3-141. MESSAGE. This command is used to display messages on the front panel display of the instrument. It expects a pointer value followed by an ASCII string. The pointer indicates the location on the display to start displaying the message. This command is only operable when the DSOFF bus command has already been executed. To clear a previous message, a DSOFF command may be sent at any time. This command is classified as a Listen Array Command.

1. **Format:** MESSAGE n [displayed message]

where:

n is the pointer which marks the beginning location of the message, from 0 to 43. See text.

displayed message is an ASCII string, up to 64 characters.

2. The message field of the display starts with the left most character on the top line and includes all 40 characters on the top line, continuing with the second line. No line feed or carriage return is to be sent.

3. The display will display 256 character types (all of the standard ASCII characters plus special ones that are in place of the control codes and upper 128 characters).

Examples:

MESSAGE 1 [Boonton Test Program 1];
MESSAGE 40 [Test in Progress];
DSOFF MESSAGE 10[This is Powermeter Number Three].

3-142. SRQMASK. This command is used to set the SRQ mask which selectively enables 4300 generated service requests. This command is classified as a Listen Parameter command.

1. The range of numeric entry is from 0 to 255. The SRQ mask is logically ANDed with the SRQ sources to determine if an SRQ should be generated. For more information on SRQ and the related serial poll, refer to section 3-111.

2. The SRQ bit map is shown in Table 3-12.

TABLE 3-12. SRQ MASK

Bit	Description
0	Bit set indicates that an instrument error has occurred.
1	Bit set indicates that a measurement error has occured.
2	Bit set indicates that a measurement is ready.
3	Bit set indicates that a zeroing command is complete.
4	Not used: should be reset.
5	Bit set indicates that front panel button is pressed.
6	Bit set indicates that an SRQ is active. (This is a summary bit used in serial poll; it is not a masked bit.)
7	Not used: should be reset.

Examples:

SRQMASK 0 — Disable all service requests.
SRQMASK 3 — Enable only SRQ on instrument and measurement errors.
SRQMASK 8 — Enable service request only when a zeroing operation is completed.

3-143. CHANSUM. This command is similar to the keyboard command CHAN E, however the format and type of data sent over the bus needs additional specification. Refer to the CHAN E key. This command is classified as a Listen Array Command.

1. **Format:** CHANSUM [n+m+p-q] (typical)

where:

n, m, p, and q are channel numbers (1-6).

2. The equation can consist of up to six channel numbers, separated only by + or - signs. Extra characters of any kind including spaces are not allowed within the equation but extra spaces or delimiters are allowed between the equation and the square brackets. The + and - signs are used without concern to the present operating units of the instrument (dBm or Watts). If the instrument is in dBm mode, the equation represents a summation of dB, and the result is in dB. If the instrument is operating in the watts mode, the + and - signs will be interpreted as multiply and divide signs, indicating a power ratio (result in percent).

Examples:

```
CHANSUM [ 1-2 ]
CHANSUM [ 1+3-2+4-5+6 ]
CHANSUM [ 3+6-4 ]
```

3-144. IEEE-448 PROGRAMMING EXAMPLES.

1. The following programming examples demonstrate the bus operation of the 4300. The examples are written in a general format of Basic and are not an example of any specific implementation of the language. The organization of the syntax is modeled after normal orientation of Basic with the command perspective, relative to the controller. The examples also assume that the 4300 is the only instrument connected and that all commands default to the address of the 4300.

2. In the examples, "input" refers to the case where the instrument is the talker; "output" indicates that the controller is the talker. The vertical slash (|) is used to mark comments.

EXAMPLE 1: Take a reading on channel 1 after zeroing the channel with the following setup:

Filter set to 1 second.
Frequency set to 5 GHz.
Reading in dBm.

Program:

```
VARIABLE  T#1,T#2,T#3,T#4,T#5,T#6

OUTPUT "RECALL 0"        | Clear all previous setups
OUTPUT "FILTER 1000"     | Set the filter to 1000 ms
OUTPUT "FREQ 5"          | Set the frequency to 5 GHz
OUTPUT "ZERO"            | Start the zeroing of the channel
OUTPUT "TALKMODE 4"      | Set talk mode to channel status
BEGIN
  WAIT 0.01              | Short delay
  INPUT T#1,T#2,T#3,T#4,T#5,T#6
                         | The 7th value can be ignored
  UNTIL T#6 = 0          | Loop until zeroing done
OUTPUT "TALKMODE 0"      | Set talk mode to measure
INPUT T#1                | T#1 contains the power in dBm
PRINT T#1                | Print the power reading
```

EXAMPLE 2: Triggered Summation Measurement.

Objective: Measure the power difference repetitively between channels 3 and 4, using channel 4 as the reference point. The measurement must be synchronized by a trigger command and only a settled reading is to be returned. Compensation must be included for a 10 dBm attenuator in line with the sensor on channel 4.

Program:

```
VARIABLE T#1

OUTPUT "CHANSUM 4-3"  | Enter summation equation
OUTPUT "SETCH 4"      | Select channel four
OUTPUT "SETREF -10"   | Enable dBr to compensate for
                      |   in line attenuator
OUTPUT "SUMENA"       | Enable the summation mode
OUTPUT "TRSETTLE"     | Set all channels to trigger settled
                      |   readings.
                      | When ready to take read
OUTPUT "TRIGGER"      | Trigger all channels in
                      |   summation mode
INPUT T#1             | The power difference returned
                      | When ready to take read
OUTPUT "TRIGGER"      | Trigger all channels in
                      |   summation mode
INPUT T#1             | The power difference returned
```

EXAMPLE 3: Change the sensor assignment and execute an autocalibration.

Objective: Assign the sensor entered into entry 7 to channel 1 and perform an automatic multi-point calibration on it.

Program:

```
VARIABLE T#1

OUTPUT "SETCH 1"      | Select channel 1
OUTPUT "ASSIGN 7"     | Assign sensor 7 to channel 1
OUTPUT "AUTOCAL"      | Initiate the autocalibration rou-
                      |   tine which will execute the
                      |   multi-pt calibration if the
                      |   correct sensor is connected to
                      |   the programmable calibrator.
| The instrument will take 2 minutes or so for this calibration
| depending on the sensor type being calibrated. Any attempt at
| bus communications will be held up until the autocal procedure
| is completed.
OUTPUT "TALKMODE 2"   | Set talk mode to talk error
INPUT T#1             | Check if autocal was performed
IF T#1 <> 0 THEN PRINT "Calibration Error check sensor"
                      | If an error has occurred then
                      |   report the error
```

3-145. ERROR MESSAGES

The error messages returned over the bus are described in Table 3-13. They are in numerical order as would be sent out over the IEEE-488 bus. The first line is the message that appears on the right hand side of the display when the error occurs and would also be sent out over the IEEE-488 bus in the talk error message mode. The paragraphs that follow each message are an explanation and provide some hints at possible causes for the error.

TABLE 3-13. ERROR MESSAGES

1 Err Range of #

An error generated when the entered value is not within the accepted range of the function expecting the number.

2 Err # of DIGITS

An error generated by keyboard entry only. It indicates the too many digits or decimal places in a number have been entered.

3 Err Under RANGE

This error can occur under two different conditions: 1) In auto-range when the power level is below -75 dBm, and 2) In hold range mode when the power level is below the level that can be measured on the present range.

4 Err Over RANGE

The error can occur under two different conditions: 1) In auto-range when the power level is above the measurement range of the sensor, and 2) In hold range when the power level is above the level that can be measured on the present range.

5 Err ERROR

This error code is presently not used.

6 Unable to Zero

One or more channels cannot perform a zero operation because the sensor(s) have a power level applied to it. Sensors will zero at power inputs less than about a full scale signal on range 0. Channels with no sensors connected will float to an undertermined level and usually appear to have power applied that is too high to zero.

7 Err ERROR

This error code is presently not used.

8 Err Sensor S/N

This error is generated when a sensor serial number is entered into the Sensor Data S/N function and no match is found (the serial number does not reside in the sensor data bank).

9 Err Zeroing Ch

This error is generated when a measurement is attempted on a channel while it is trying to perform a zeroing operation.

10 Not Supported

This error response indicates that an attempt is being made to use a feature or command which is not available in this version of the instrument or in the present operating mode.

11 Err Low Limit

This error indicates that the present power reading is below the low limit setup for that channel. Refer to the LO LIMIT key. A blinking down arrow also appears between the channel number and the power reading on the front panel display.

12 Err High Limit

This error indicates that the present power reading is above the high limit setup for that channel. Refer to the HI LIMIT key. A blinking up arrow also appears between the channel number and the power reading on the front panel display.

13 Err Measurement

This error message indicates an error in the measurement parameters so the resulting measurement values are not normally acceptable but the operator might choose to use them.

14 No Channel Card

This error message is generated when a channel is selected that has no card installed or the card is not operating in the normally expected fashion. This error is only generated in response to the SET CH (Set Channel) function.

15 No Calibrator

This error message indicates that no 30 MHz programmable calibrator is installed. The fixed 50 MHz calibrator is not related to this message.

TABLE 3-13. ERROR MESSAGES (Cont.)

16 Battery Failure

This error is generated by the battery test which is performed at power on and upon request. The only difference between this error and error number 58 is that this message indicates the error is on the control board by the use of the (MOD) string. When this error occurs the channels or the control board can cause the failure. The failing subsection of the instrument can be identified by the channel error number in the talk error message and also on the front panel display on the bottom line of the error reporting field.

17 Err Chan Card

This error is generated by the channel when it determines that a subsection of its own board is not working properly.

18 Err Memory Test

This error is generated by the memory test which is performed at power on and upon request. Both channel and control board memory faults can cause this error. The failing subsection can be identified by the channel error number in the talk error and also on the front panel display.

19 Err ERROR

This error code is presently not used.

20 Err Raw Measure

This error is generated when a channel is commanded to go to the raw data mode and, because of the operating mode, it cannot. The modes that will generate this error are the duty cycle mode and the summation mode.

21 Chan Mode Only

This error is generated when a special calibration operation is selected which can only be performed in the single channel mode.

22 Err E Equation

This error message is caused by the improper entry of the equation that is used for the summation mode. One case when entered from the keyboard is that less than two or more than six numbers have been entered. On the bus it could be illegal syntax, an improper message format or illegal string characters.

23 Err Cal Limit

This error is generated when a calibrator level is entered that exceeds the calibrator limit previously stored in the instrument. Refer to the Calibrator Limit key. When this error occurs the cal level is not changed because this feature is used to protect a power sensitive device connected to the calibrator.

24 Out of Freq Rng

This error is generated when a frequency is entered into the Freq function that is out of range of the previously entered sensor data. Refer to the FREQ key. For proper operation, the frequency points must be in numerical order starting with the smallest first. It is recommended that the first entry be the lowest number that might ever be used with the instrument.

25 Err Sensor Type

This error message only occurs as part of the sensor entry function. This response indicates that the sensor type entered is not resident in the firmware.

26 Err ERROR

This error code is presently not used.

27 Err ERROR

This error code is presently not used.

28 Err Pulse Meas

This error is reported as a measurement error in the duty cycle mode and indicates that a diode sensor is operating out of the square law region and that the calculated duty cycle is incorrect.

29 Err Recall Data.

The instrument setup register is corrupted or invalid.

30 Err Bus Buffer

This error message occurs only when the IEEE-488 bus is used and the instrument listen operation receives a string greater than 512 characters which causes the internal buffer to be exceeded. When this occurs all of the commands in the message are ignored. The only time that this is likely to be a problem is when sending an FNC in MATE. In this case, two consecutive FNC strings can be sent. If the error occurs after a series of short messages then it may be that the terminator characters are not correct or the EOI is not being sent, causing the instrument to interpret multiple messages as one string.

TABLE 3-13. ERROR MESSAGES (Cont.)

31 Err Bus Command

This error is generated by the reception over the bus of a command string that is unrecognized by the instrument. To assist in bus debugging refer to the bus test feature. See the TEST key.

32 Err Bus String

This error indicates that the bus buffer or teach and learn block modes are not partitioned properly by square brackets.

33 Err ERROR

This error code is presently not used.

34 Err AC CAL ###

This error is generated during the execution of automatic AC 14 Point Calibration for the sensors. the ### is the first level in dBm at which the instrument was unable to generate new correction factors.

35 Err Sensor Cal

This error occurs when a multipoint calibration (autocalibration) is attempted on a channel that has a waveguide sensor assigned to it.

36 Multi-Pt Err###

This error occurs in response to an autocal request. it indicates that the sensor is connected to the programmable calibrator but the power readings are out of the expected windows. A check for poor connection path or external attenuator still in the path should be done. The ### is the power level in dBm where the first failure occurred. To verify the error check the level indicated by the ### value by hand on the instrument. This would indicate if the calibrator has failed at that specific point.

37 AutoCal Error

Similar to Error 36, but is generated at a different point in the routine. No power level is returned. A check for proper sensor type, poor connection path or external attenuator still in the path should be done.

38 Err Cal Exited

This message is not an error per se because it can only be generated by operator intervention. This is the response to pressing the ESC key during the autocal procedure. It is necessary to inform the operator or computer that the operation was aborted.

39 Err Fixed Cal

This error message occurs when the autocal procedure is selected but the sensor is not connected to the programmable calibrator. This could be that the calibration is not at or close to the 0 dBm or -20 dBm points which are the only fixed point cal levels supported. Other causes for error are wrong sensor type assigned, external signal path loss, or instrument malfunction.

40 Protected Data

This error occurs if sensor data, calibration data, or DC channel card calibration is being accessed while an internal or rear panel bitswitch is set to protect this data. Also, the 30 MHz programmable calibrator has a jumper which protects the calibration data. Refer to the Adjustments section for information on how to unprotect the data

41 Err Cal Signal

The measured signal in the autocalibration operation is out of range.

42 Err ERROR

This error code is presently not used.

43 Err ERROR

This error code is presently not used.

44 Err ERROR

This error code is presently not used.

45 Err ERROR

This error code is presently not used.

46 Err ERROR

This error code is presently not used.

47 No CILL Present

This error message is generated when the bus command CIIL is issued or bitswitch 4 is set to the open on an instrument that does not have the MATE option installed.

SECTION 4
MAKING MEASUREMENTS

4-1. INTRODUCTION.

This section contains information on specific types of measurements that can be made, and details regarding ordinary measurements and their accuracies. It is assumed that the reader is familiar with the basic front panel operation and the keystroke sequences. This section contains the following topics:

1. Sensor Calibration
2. Zeroing
3. Filtering
4. Measurement time
5. High frequency accuracy
6. Pulsed RF measurements
7. Chart recorder operation
8. Triggered operation and Settled Reading
9. Waveform sensitivity

4-2. SENSOR CALIBRATION.

Two types of calibration are associated with the 4300, instrument calibration and sensor calibration. The instrument (less sensors) must be calibrated using a DC source to ensure interchangability of sensors (i.e., to ensure compatibility of all 4300's). The calibration procedures are covered in Section 6, Maintenance. Sensor calibration theory is discussed below.

Calibration data for up to 20 sensors is stored in non-volatile RAM. Sensor calibration is of two types: linearity and high frequency cal factors. These are discussed below.

1. **14-Point Linearity Data.** For the case where the 30 MHz programmable calibrator is not installed, or when millimeter wave sensors are used, the linearity data (also referred to as AC reference frequency linearity data) is supplied with the sensor and is manually entered at time of purchase. Instruments shipped from the factory already have the data installed. Refer to Figure 4-1.

At the reference frequency (30, 50 MHz or 22, 33, 40, 60 or 94 HGz), each sensor has two gain factors for each range: upscale and downscale points. The upscale points are in the range of 5000 which is a gain correction factor. The upscale point is calibrated at the factory at about 70% of full scale. The downscale number is a second order type of correction at about 25% of full scale. Thus for a diode sensor (7 ranges) there are 14 points. For thermal sensors there are 8 points. Ranges 0 and 1 share the same data points.

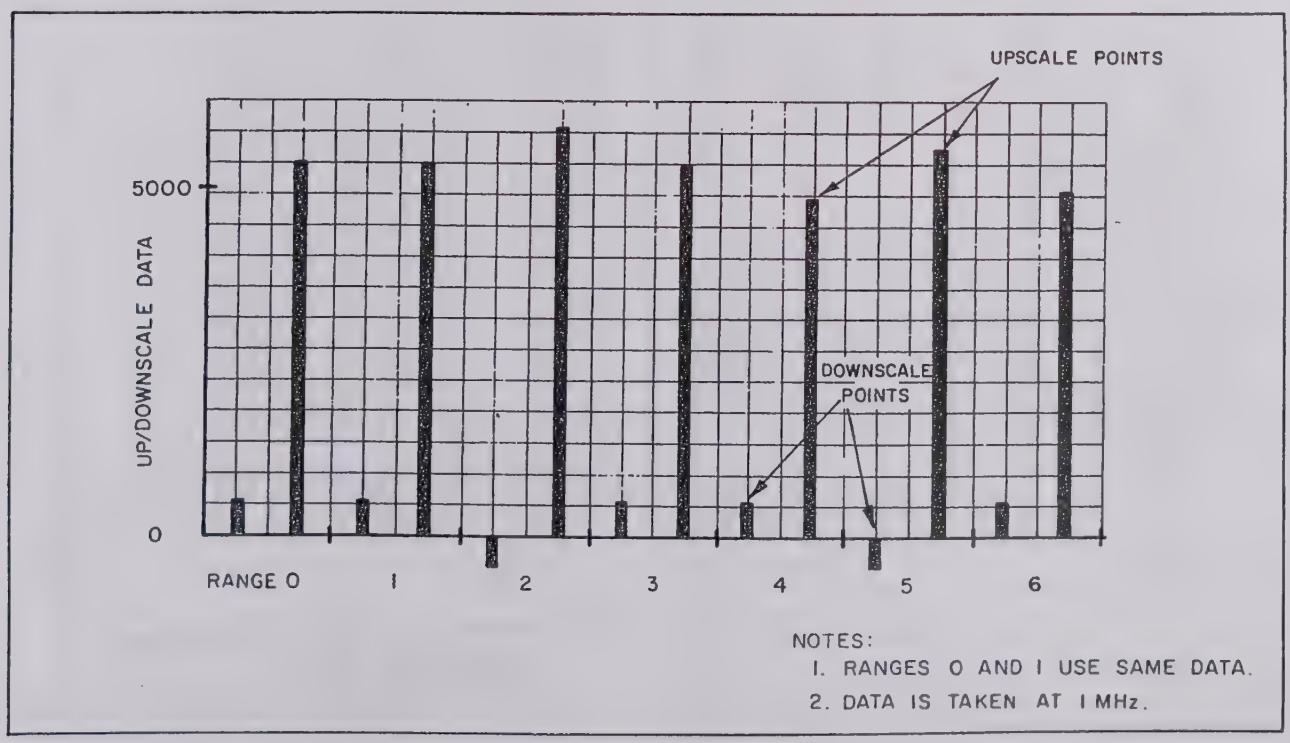


Figure 4-1. 14 Point Sensor Calibration

2. **Autocal Generation of Linearity.** If the 30 MHz Calibrator is to be used instead of the 14 Point linearity data, this function is simply executed by connecting the sensor to the calibrator and pressing AUTO CAL. The sensor type must be programmed and the sensor must be assigned to the applicable channel. Several points per range are calibrated in the peak transition regions of the sensor. The points may be as close as 1 dB apart in the peak and transition regions of the sensor. This is shown for a typical sensor in Figure 4-2. Not all points are shown. The power points are sensor dependent and are stored in the program.

Because of the close spacing, auto calibration reduces linearity errors to nearly zero. The 30 MHz Calibrator has its power points referenced to 0 dBm through an NBS traceable attenuation standard, good to .006 dB/10 dB (NBS does not certify attenuation at 50 MHz; when using the 14 point method of calibration the linearity calibration is done at 1 MHz. Other power meter techniques assume the linearity of the sensor and calibrate only at 0 dBm).

The 30 MHz Calibrator limit is +20 dBm, therefore, for sensors whose top limit is above +20 dBm, extrapolation is done in the auto calibration cycle.

The Autocal routine also compensates for any channel module inaccuracy. Therefore, when this mode is used, DC calibration of the 4300 need not be done. The autocal data is stored with the channel module, not in the sensor data bank and is not transferrable to other channels. If a sensor is assigned to another channel, it must be auto calibrated again.

Autocalibration of a sensor/channel adds correction on top of the "14 point" data if it has been previously stored. This increases the accuracy of the extrapolation of the sensors above +20 dBm; the top range(s) can be adjusted independently of the lower ranges.

3. **High Frequency Cal Points.** In addition to linearity data there are high frequency points as shown in Figure 4-3. Calibration points covering the entire sensor frequency range are supplied with each sensor. Below 2 GHz the response is flat and the frequency cal points need not be entered.

Figure 4-3 shows data for 17 points; however, space for up to 80 points per sensor (sensors 1-6) is provided in the non-volatile RAM (35 points for sensors 7-20). The frequency cal points need not be in equal frequency increments, however, the entry of data must be done in order of frequency. Generally a cal factor of 0 dB is

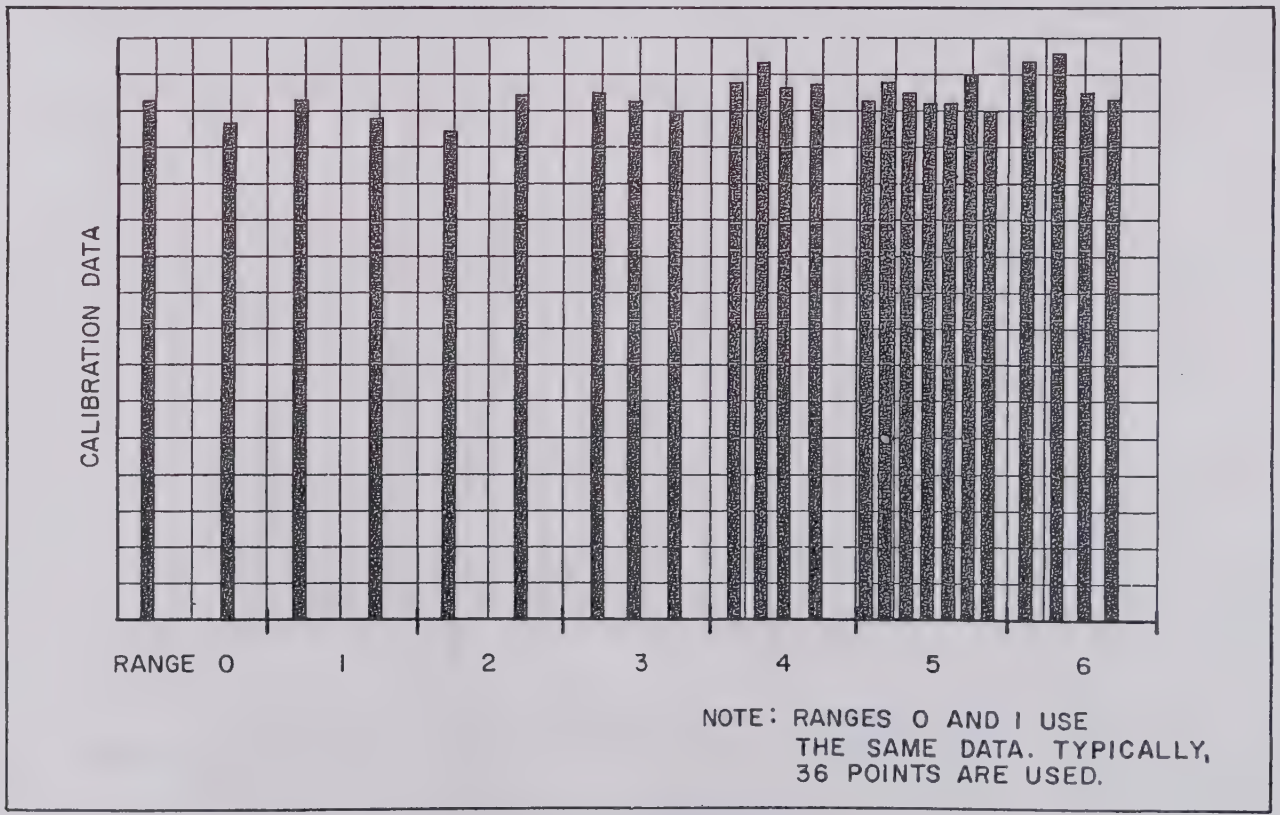


Figure 4-2. Autocalibration of Sensor

1. **Format:** CHANSUM [n+m+p-q] (typical)

where:

n, m, p, and q are channel numbers (1-6).

2. The equation can consist of up to six channel numbers, separated only by + or - signs. Extra characters of any kind including spaces are not allowed within the equation but extra spaces or delimiters are allowed between the equation and the square brackets. The + and - signs are used without concern to the present operating units of the instrument (dBm or Watts). If the instrument is in dBm mode, the equation represents a summation of dB, and the result is in dB. If the instrument is operating in the watts mode, the + and - signs will be interpreted as multiply and divide signs, indicating a power ratio (result in percent).

Examples:

```
CHANSUM [ 1-2 ]
CHANSUM [ 1+3-2+4-5+6 ]
CHANSUM [ 3+6-4 ]
```

3-144. IEEE-448 PROGRAMMING EXAMPLES.

1. The following programming examples demonstrate the bus operation of the 4300. The examples are written in a general format of Basic and are not an example of any specific implementation of the language. The organization of the syntax is modeled after normal orientation of Basic with the command perspective, relative to the controller. The examples also assume that the 4300 is the only instrument connected and that all commands default to the address of the 4300.

2. In the examples, "input" refers to the case where the instrument is the talker; "output" indicates that the controller is the talker. The vertical slash (|) is used to mark comments.

EXAMPLE 1: Take a reading on channel 1 after zeroing the channel with the following setup:

Filter set to 1 second.
Frequency set to 5 GHz.
Reading in dBm.

Program:

```
VARIABLE   T#1,T#2,T#3,T#4,T#5,T#6

OUTPUT "RECALL 0"       | Clear all previous setups
OUTPUT "FILTER 1000"    | Set the filter to 1000 ms
OUTPUT "FREQ 5"         | Set the frequency to 5 GHz
OUTPUT "ZERO"           | Start the zeroing of the channel
OUTPUT "TALKMODE 4"     | Set talk mode to channel status
BEGIN
  WAIT 0.01             | Short delay
  INPUT T#1,T#2,T#3,T#4,T#5,T#6
                        | The 7th value can be ignored
  UNTIL T#6 = 0         | Loop until zeroing done
OUTPUT "TALKMODE 0"     | Set talk mode to measure
INPUT T#1               | T#1 contains the power in dBm
PRINT T#1               | Print the power reading
```

EXAMPLE 2: Triggered Summation Measurement.

Objective: Measure the power difference repetitively between channels 3 and 4, using channel 4 as the reference point. The measurement must be synchronized by a trigger command and only a settled reading is to be returned. Compensation must be included for a 10 dBm attenuator in line with the sensor on channel 4.

Program:

```
VARIABLE T#1

OUTPUT "CHANSUM 4-3"    | Enter summation equation
OUTPUT "SETCH 4"        | Select channel four
OUTPUT "SETREF -10"     | Enable dBr to compensate for
                        |   in line attenuator
OUTPUT "SUMENA"         | Enable the summation mode
OUTPUT "TRSETTLE"       | Set all channels to trigger settled
                        |   readings
                        | When ready to take read
OUTPUT "TRIGGER"        | Trigger all channels in
                        |   summation mode
INPUT T#1               | The power difference returned
                        | When ready to take read
OUTPUT "TRIGGER"        | Trigger all channels in
                        |   summation mode
INPUT T#1               | The power difference returned
```

EXAMPLE 3: Change the sensor assignment and execute an autocalibration.

Objective: Assign the sensor entered into entry 7 to channel 1 and perform an automatic multi-point calibration on it.

Program:

```
VARIABLE T#1

OUTPUT "SETCH 1"        | Select channel 1
OUTPUT "ASSIGN 7"       | Assign sensor 7 to channel 1
OUTPUT "AUTOCAL"        | Initiate the autocalibration rou-
                        |   tine which will execute the
                        |   multi-pt calibration if the
                        |   correct sensor is connected to
                        |   the programmable calibrator.
| The instrument will take 2 minutes or so for this calibration
| depending on the sensor type being calibrated. Any attempt at
| bus communications will be held up until the autocal procedure
| is completed.
OUTPUT "TALKMODE 2"     | Set talk mode to talk error
INPUT T#1               | Check if autocal was performed
IF T#1 <> 0 THEN PRINT "Calibration Error check sensor"
                        | If an error has occurred then
                        |   report the error.
```

3-145. ERROR MESSAGES

The error messages returned over the bus are described in Table 3-13. They are in numerical order as would be sent out over the IEEE-488 bus. The first line is the message that appears on the right hand side of the display when the error occurs and would also be sent out over the IEEE-488 bus in the talk error message mode. The paragraphs that follow each message are an explanation and provide some hints at possible causes for the error.

TABLE 3-13. ERROR MESSAGES

1 Err Range of #

An error generated when the entered value is not within the accepted range of the function expecting the number.

2 Err # of DIGITS

An error generated by keyboard entry only. It indicates the too many digits or decimal places in a number have been entered.

3 Err Under RANGE

This error can occur under two different conditions: 1) In auto-range when the power level is below -75 dBm, and 2) In hold range mode when the power level is below the level that can be measured on the present range.

4 Err Over RANGE

The error can occur under two different conditions: 1) In auto-range when the power level is above the measurement range of the sensor, and 2) In hold range when the power level is above the level that can be measured on the present range.

5 Err ERROR

This error code is presently not used.

6 Unable to Zero

One or more channels cannot perform a zero operation because the sensor(s) have a power level applied to it. Sensors will zero at power inputs less than about a full scale signal on range 0. Channels with no sensors connected will float to an undertermined level and usually appear to have power applied that is too high to zero.

7 Err ERROR

This error code is presently not used.

8 Err Sensor S/N

This error is generated when a sensor serial number is entered into the Sensor Data S/N function and no match is found (the serial number does not reside in the sensor data bank).

9 Err Zeroing Ch

This error is generated when a measurement is attempted on a channel while it is trying to perform a zeroing operation.

10 Not Supported

This error response indicates that an attempt is being made to use a feature or command which is not available in this version of the instrument or in the present operating mode.

11 Err Low Limit

This error indicates that the present power reading is below the low limit setup for that channel. Refer to the LO LIMIT key. A blinking down arrow also appears between the channel number and the power reading on the front panel display.

12 Err High Limit

This error indicates that the present power reading is above the high limit setup for that channel. Refer to the HI LIMIT key. A blinking up arrow also appears between the channel number and the power reading on the front panel display.

13 Err Measurement

This error message indicates an error in the measurement parameters so the resulting measurement values are not normally acceptable but the operator might choose to use them.

14 No Channel Card

This error message is generated when a channel is selected that has no card installed or the card is not operating in the normally expected fashion. This error is only generated in response to the SET CH (Set Channel) function.

15 No Calibrator

This error message indicates that no 30 MHz programmable calibrator is installed. The fixed 50 MHz calibrator is not related to this message.

TABLE 3-13. ERROR MESSAGES (Cont.)

16 Battery Failure

This error is generated by the battery test which is performed at power on and upon request. The only difference between this error and error number 58 is that this message indicates the error is on the control board by the use of the (MOD) string. When this error occurs the channels or the control board can cause the failure. The failing subsection of the instrument can be identified by the channel error number in the talk error message and also on the front panel display on the bottom line of the error reporting field.

17 Err Chan Card

This error is generated by the channel when it determines that a subsection of its own board is not working properly.

18 Err Memory Test

This error is generated by the memory test which is performed at power on and upon request. Both channel and control board memory faults can cause this error. The failing subsection can be identified by the channel error number in the talk error and also on the front panel display.

19 Err ERROR

This error code is presently not used.

20 Err Raw Measure

This error is generated when a channel is commanded to go to the raw data mode and, because of the operating mode, it cannot. The modes that will generate this error are the duty cycle mode and the summation mode.

21 Chan Mode Only

This error is generated when a special calibration operation is selected which can only be performed in the single channel mode.

22 Err E Equation

This error message is caused by the improper entry of the equation that is used for the summation mode. One case when entered from the keyboard is that less than two or more than six numbers have been entered. On the bus it could be illegal syntax, an improper message format or illegal string characters.

23 Err Cal Limit

This error is generated when a calibrator level is entered that exceeds the calibrator limit previously stored in the instrument. Refer to the Calibrator Limit key. When this error occurs the cal level is not changed because this feature is used to protect a power sensitive device connected to the calibrator.

24 Out of Freq Rng

This error is generated when a frequency is entered into the Freq function that is out of range of the previously entered sensor data. Refer to the FREQ key. For proper operation, the frequency points must be in numerical order starting with the smallest first. It is recommended that the first entry be the lowest number that might ever be used with the instrument.

25 Err Sensor Type

This error message only occurs as part of the sensor entry function. This response indicates that the sensor type entered is not resident in the firmware.

26 Err ERROR

This error code is presently not used.

27 Err ERROR

This error code is presently not used.

28 Err Pulse Meas

This error is reported as a measurement error in the duty cycle mode and indicates that a diode sensor is operating out of the square law region and that the calculated duty cycle is incorrect.

29 Err Recall Data.

The instrument setup register is corrupted or invalid.

30 Err Bus Buffer

This error message occurs only when the IEEE-488 bus is used and the instrument listen operation receives a string greater than 512 characters which causes the internal buffer to be exceeded. When this occurs all of the commands in the message are ignored. The only time that this is likely to be a problem is when sending an FNC in MATE. In this case, two consecutive FNC strings can be sent. If the error occurs after a series of short messages then it may be that the terminator characters are not correct or the EOI is not being sent, causing the instrument to interpret multiple messages as one string.

TABLE 3-13. ERROR MESSAGES (Cont.)

31 Err Bus Command

This error is generated by the reception over the bus of a command string that is unrecognized by the instrument. To assist in bus debugging refer to the bus test feature. See the TEST key.

32 Err Bus String

This error indicates that the bus buffer or teach and learn block modes are not partitioned properly by square brackets.

33 Err ERROR

This error code is presently not used.

34 Err AC CAL ###

This error is generated during the execution of automatic AC 14 Point Calibration for the sensors. the ### is the first level in dBm at which the instrument was unable to generate new correction factors.

35 Err Sensor Cal

This error occurs when a multipoint calibration (autocalibration) is attempted on a channel that has a waveguide sensor assigned to it.

36 Multi-Pt Err###

This error occurs in response to an autocal request. it indicates that the sensor is connected to the programmable calibrator but the power readings are out of the expected windows. A check for poor connection path or external attenuator still in the path should be done. The ### is the power level in dBm where the first failure occurred. To verify the error check the level indicated by the ### value by hand on the instrument. This would indicate if the calibrator has failed at that specific point.

37 AutoCal Error

Similar to Error 36, but is generated at a different point in the routine. No power level is returned. A check for proper sensor type, poor connection path or external attenuator still in the path should be done.

38 Err Cal Exited

This message is not an error per se because it can only be generated by operator intervention. This is the response to pressing the ESC key during the autocal procedure. It is necessary to inform the operator or computer that the operation was aborted.

39 Err Fixed Cal

This error message occurs when the autocal procedure is selected but the sensor is not connected to the programmable calibrator. This could be that the calibration is not at or close to the 0 dBm or -20 dBm points which are the only fixed point cal levels supported. Other causes for error are wrong sensor type assigned, external signal path loss, or instrument malfunction.

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This error occurs if sensor data, calibration data, or DC channel card calibration is being accessed while an internal or rear panel bitswitch is set to protect this data. Also, the 30 MHz programmable calibrator has a jumper which protects the calibration data. Refer to the Adjustments section for information on how to unprotect the data.

41 Err Cal Signal

The measured signal in the autocalibration operation is out of range.

42 Err ERROR

This error code is presently not used.

43 Err ERROR

This error code is presently not used

44 Err ERROR

This error code is presently not used.

45 Err ERROR

This error code is presently not used.

46 Err ERROR

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47 No CILL Present

This error message is generated when the bus command CIIL is issued or bitswitch 4 is set to the open on an instrument that does not have the MATE option installed.

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MAKING MEASUREMENTS

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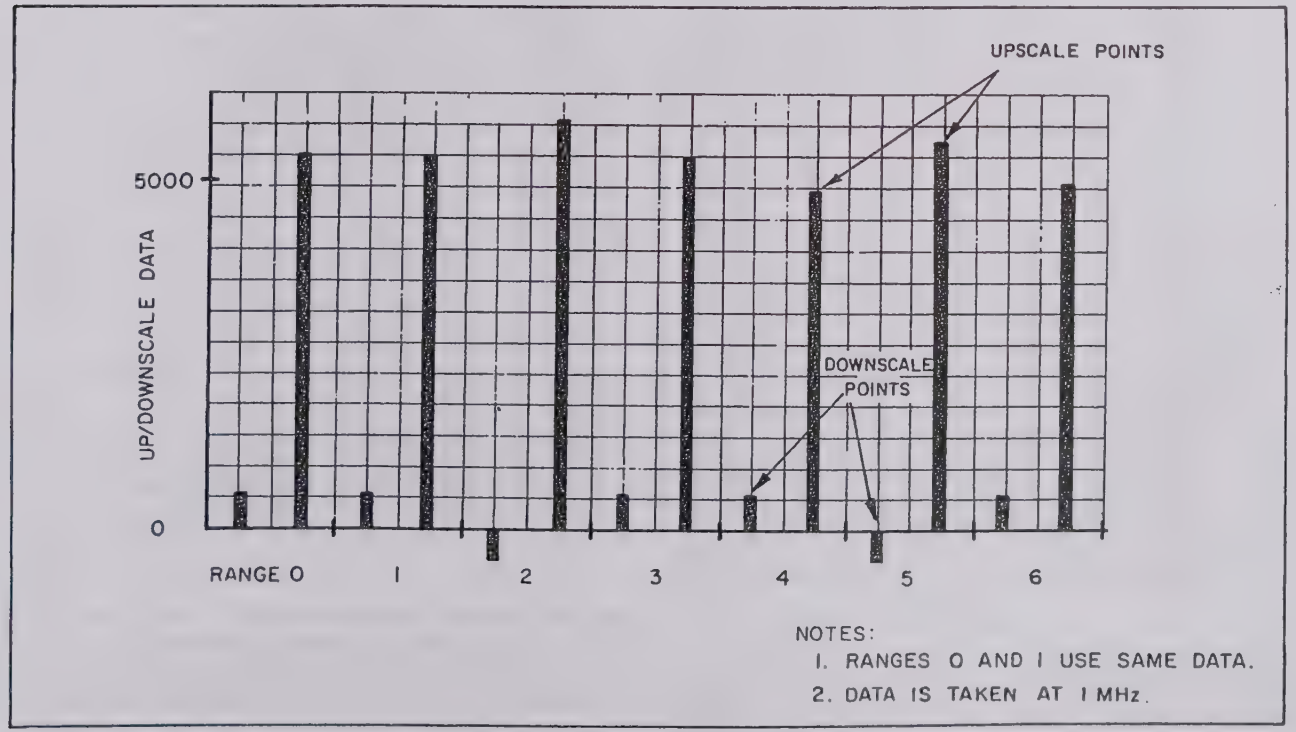

Figure 4-1. 14 Point Sensor Calibration

2. **Autocal Generation of Linearity.** If the 30 MHz Calibrator is to be used instead of the 14 Point linearity data, this function is simply executed by connecting the sensor to the calibrator and pressing AUTO CAL. The sensor type must be programmed and the sensor must be assigned to the applicable channel. Several points per range are calibrated in the peak transition regions of the sensor. The points may be as close as 1 dB apart in the peak and transition regions of the sensor. This is shown for a typical sensor in Figure 4-2. Not all points are shown. The power points are sensor dependent and are stored in the program.

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The 30 MHz Calibrator limit is +20 dBm; therefore, for sensors whose top limit is above +20 dBm, extrapolation is done in the auto calibration cycle.

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3. **High Frequency Cal Points.** In addition to linearity data there are high frequency points as shown in Figure 4-3. Calibration points covering the entire sensor frequency range are supplied with each sensor. Below 2 GHz the response is flat and the frequency cal points need not be entered.

Figure 4-3 shows data for 17 points; however, space for up to 80 points per sensor (sensors 1-6) is provided in the non-volatile RAM (35 points for sensors 7-20). The frequency cal points need not be in equal frequency increments, however, the entry of data must be done in order of frequency. Generally a cal factor of 0 dB is

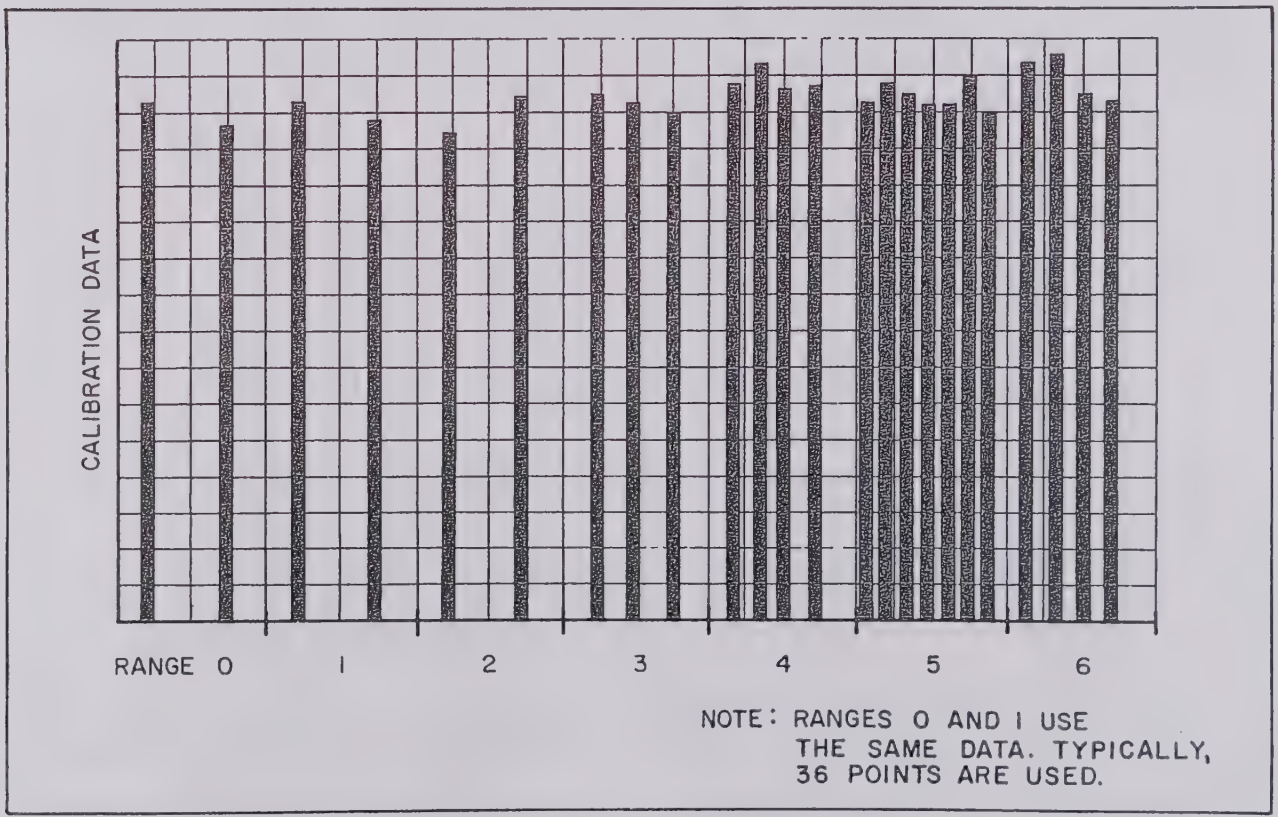

Figure 4-2. Autocalibration of Sensor

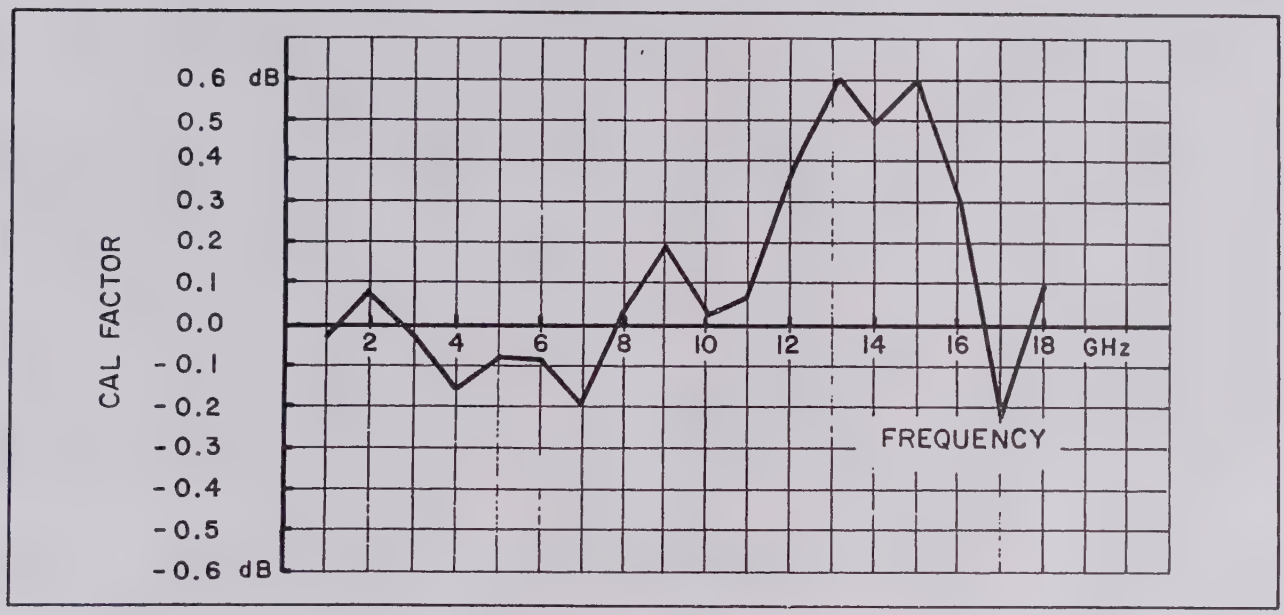

Figure 4-3. Typical High Frequency Sensor Calibration

entered at .01 GHz so that the unit may be operated below the first data point.

During measurement frequency points are linearly interpolated, and if a measurement frequency is entered outside the range of any sensor whose channel is displayed, an error message is generated.

4. **Sensor Data Entry.** The entry procedure for 14 point calibration and high frequency calibration is initiated by pressing the "SENSOR ENTRY" key. The instrument will prompt the user for information. See the Operating Section for details, however, the procedure should be self evident by following the prompts. Information is entered in the following sequence: sensor number (1-20), type, serial number, upscale points (scroll can be used to bypass these), downscale points, and the high frequency cal factors. ESCAPE can be pressed at any time to exit the routine.

4-3. ZEROING.

The automatic zeroing routine takes measurements on the bottom 5 ranges and applies these as correction factors on subsequent measurements. Offsets in the sensor and input amplifiers are linearly corrected in the internal software. Offsets on the top ranges are below .02% of full scale and do not need correction.

The input power to the sensor must be removed before the zeroing function is executed or an error message will be generated. The 4300 will do the zero however, if the signal is less than full scale on Range 0. This feature provides for a great deal of offset capability for from temperature, effects, etc., without rezeroing the input amplifier hardware.

For full accuracy at low signal levels, power must be removed from the sensor several seconds before zeroing to allow the sensor to settle. This is especially true if a large signal has been applied to the sensor in the previous 20 seconds or so, because of the dielectric absorption of the capacitors in the diode sensors, and because of the thermal retention in the thermal sensors. The error resulting from different input conditions can be determined by examining Figure 4-4, Diode Sensor Decay and Figure 4-5, Thermal Sensor Decay. The curves show the decay of measured power after a large signal has been applied. The typical error that can be expected by zeroing too quickly is equal to the offset power at the time of zeroing.

The 4300 waits for 2 seconds when the zero key is pressed before zeroing to account for typcial decay conditions and typical accuracy requirements. The user must add a delay according to the system requirements when the sensors are used over a wide dynamic range. For example, if it is determined from the application that 5 seconds is required from power off to the zero operation, then the user should wait 3 seconds after removing power before pressing ZERO.

When the chart recorder output is used as a hardware zero output to disable the source, this TTL signal goes low immediately. The overall zero sequence is as follows:

a. Waits for 500 msec.

b. Makes a trial measurement to check for no signal, displaying "CHECKING" (an error message will be indicated if a signal is present.)

c. Waits 2 seconds for the sensor to settle, displaying "SETTLING".

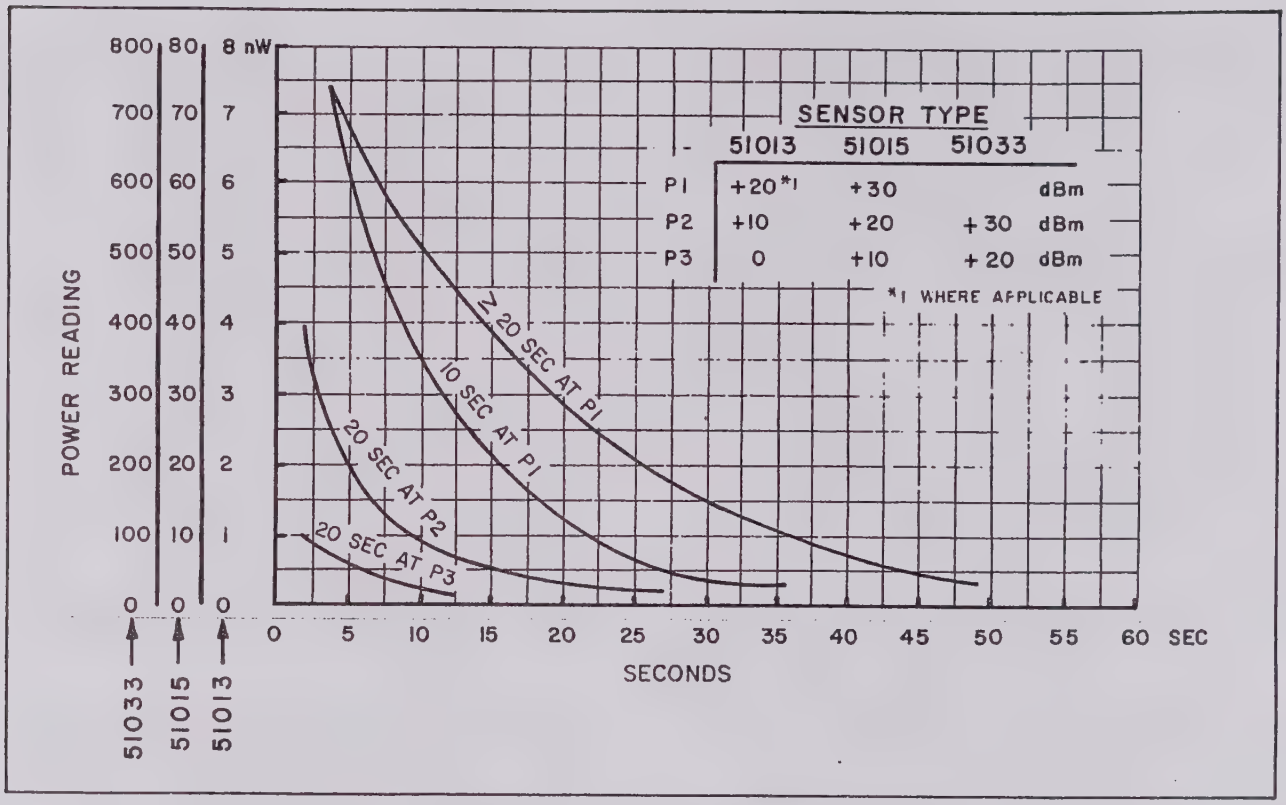

Figure 4-4. Diode Sensor Decay

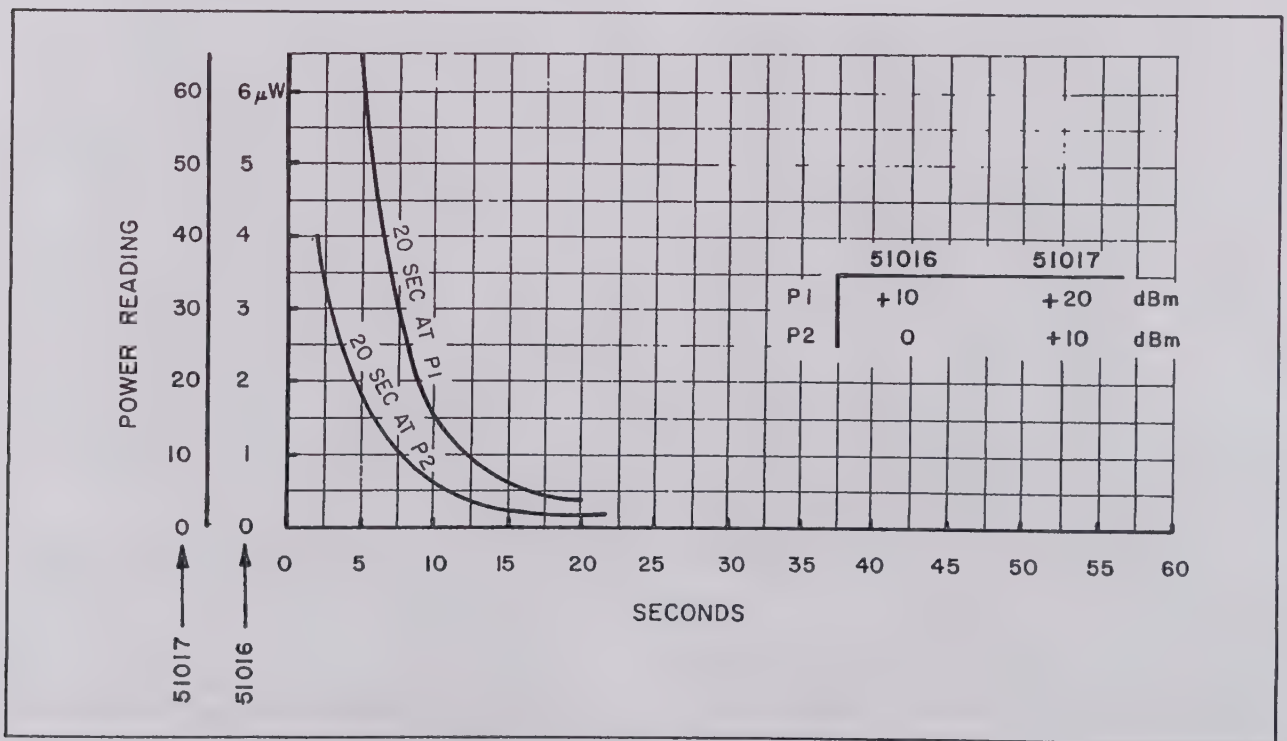

Figure 4-5. Thermal Sensor Decay

d. Zeroes ranges 4 through 0 in that order, displaying "ZEROING".

The zeroing/averaging time on each range has been optimized as a function of the filter length for speed and accuracy. The total zeroing time takes about 12 seconds for the default filter lengths, 5 seconds for minimum filtering (20 msec all ranges), and 30 seconds for maximum filtering. If desired, the filter length can be modified prior to zeroing and set back to its original value after zeroing, however this is somewhat counterproductive since when long filtering is used for measurement, then long filtering is usually desired for zeroing. There is the case, however, where power levels are at a medium level and long filtering is used (for filtering of source variations) and it is not necessary to use a long filter for zeroing. This would be the time to implement a temporary filter decrease.

Zeroing should be done when the sensor has drifted a significant amount with respect to the signal being measured. For large signals this may be once every several hours if at all. For very small signals it is recommended that zeroing be done just before a measurement.

Dynamic Range. The Hold Range mode is useful when it is known that the signal will vary over a certain limited range. In this mode, the decimal point and units will remain fixed. The dynamic range of this mode is limited by the zero offset and the resolution, as shown in Figure 4-6. Extended Hold Range Mode. It can be seen that the useful dynamic range is 20 dB if the error is to be kept less than 0.1 dB.

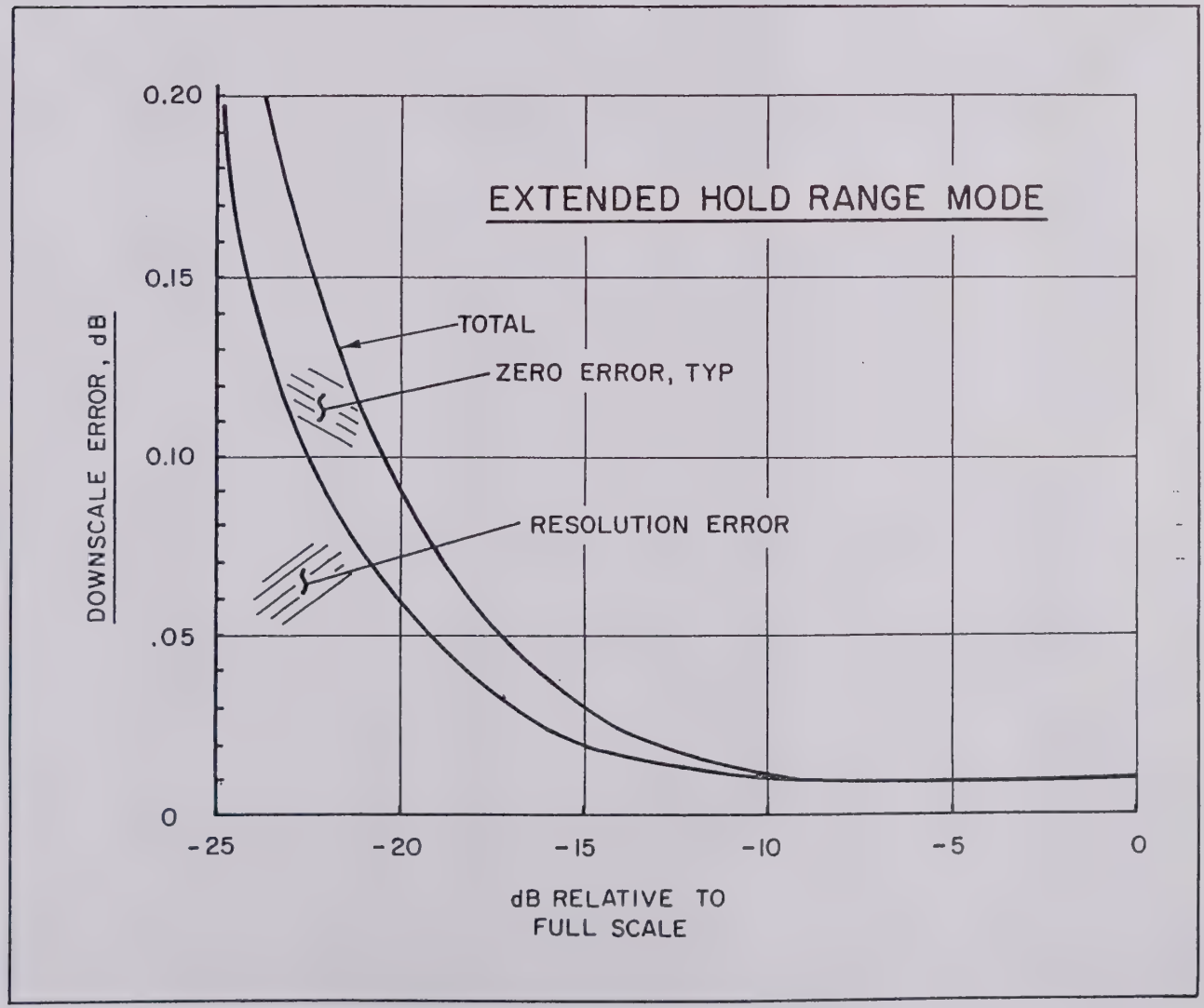

Figure 4-6. Extended Hold Range Mode

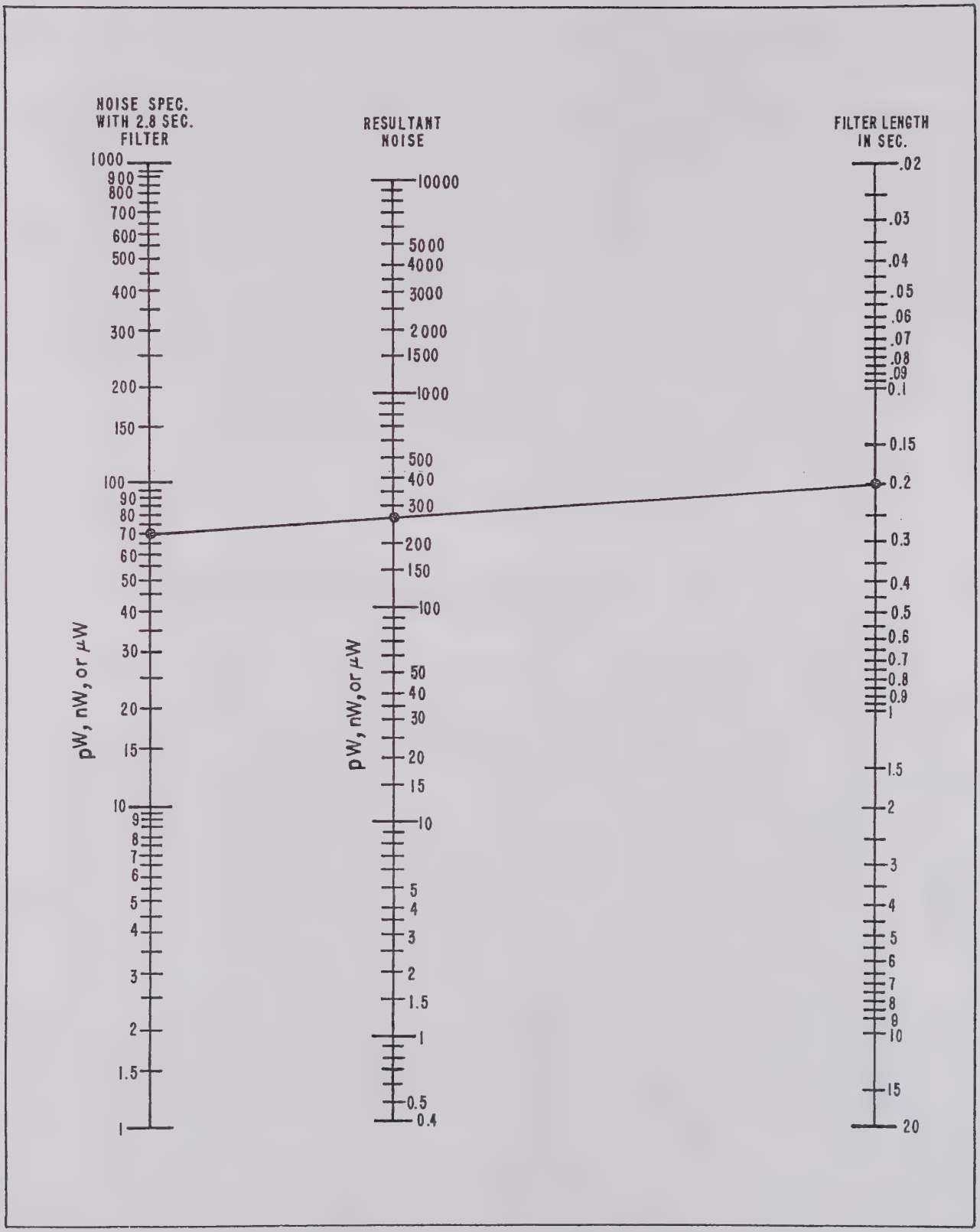

Figure 4-7. Noise Reduction for Universal Channels

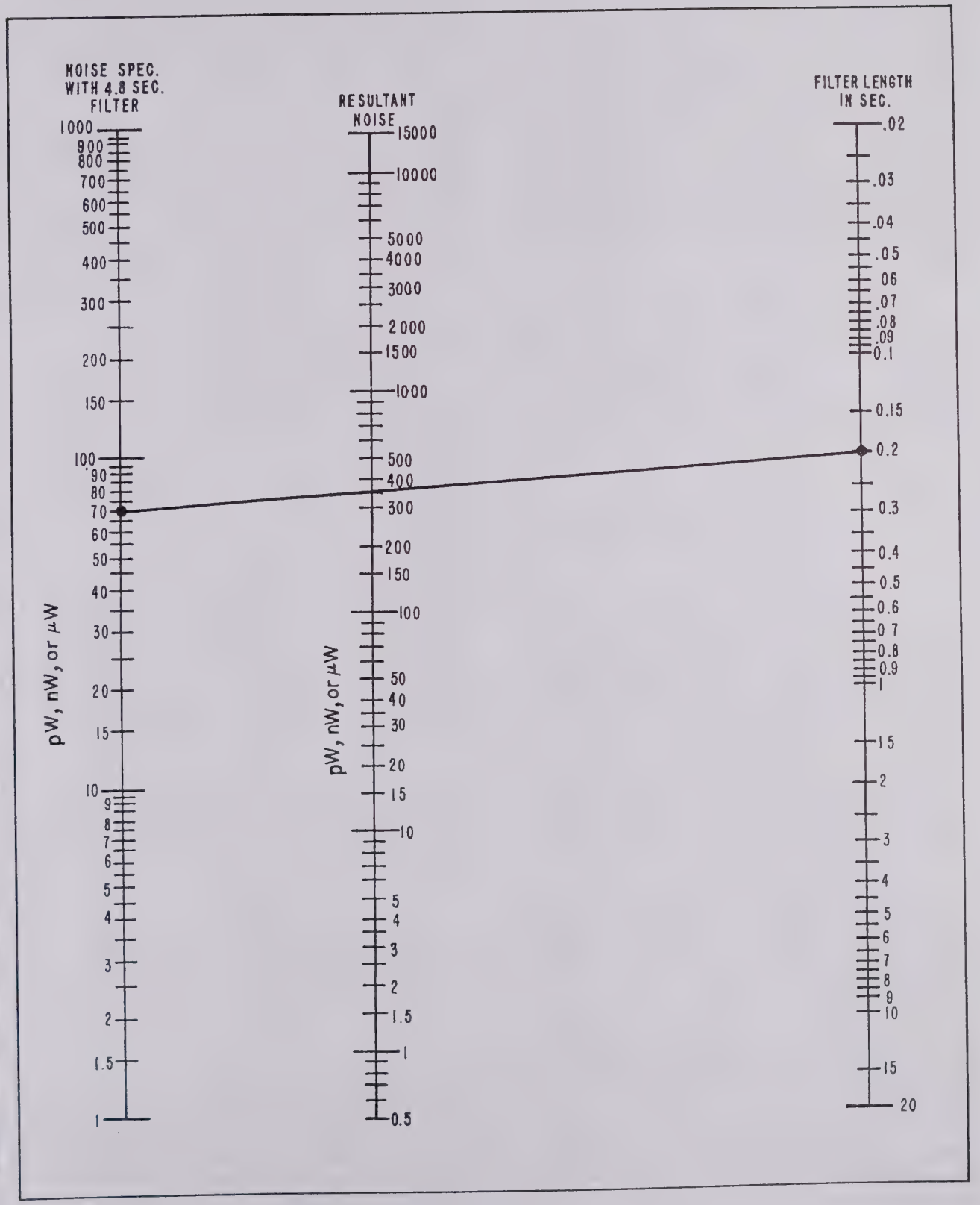

Figure 4-8. Noise Reduction for Thermal Channels

4-4. FILTERING AND NOISE.

The 4300 employs digital filtering, or averaging of measurements to reduce the noise floor of the instrument and to stabilize the measurements. Selectable averaging of up to 1000 samples is used, at an input channel sampling rate of 20 msec, which corresponds to a maximum filter time of 20 seconds. The minimum filtering is one sample or 20 msec. Alternatively, the 4300 can be programmed to use default filter lengths which are a function of the range. These numbers are optimized for speed and low noise under general conditions. Refer to Table 4-1. Default Filters for a listing of the default lengths.

TABLE 4-1. DEFAULT FILTERS

Range	Universal Input Channel	Thermal Input Channel
0	2.8 Sec	4.8 Sec
1	0.8	1.8
2	0.3	0.6
3	0.06	0.3
4	0.06	—
5	0.06	—
6	0.06	—

The technique is digital pipeline filtering, also referred to as circular filtering or moving average filtering. The displayed power is simply an equally weighted average of the last x seconds worth of samples, where x is the filter length in seconds. For purposes of noise and settling time, the number of samples is not important, but rather the time is. That is, if a 3 second filter is used, the noise is the same whether 60 or 600 samples are taken in that interval, providing that the samples are taken above a certain rate. Therefore, the 4300 filter selection is done in milliseconds rather than the number of samples.

The bottom end sensitivity is limited by sensor noise. An RMS noise specification is valid since the sensor and amplifier noise are bandlimited and Gaussian. The noise level, specified in picowatts at a certain filter length, is sufficient to calculate the error due to noise at any signal level, for any filter, as shown below.

1. **Noise Reduction.** The amount of noise reduction that can be realized has no theoretical limitation, except that drift enters the picture at filter lengths over 20 seconds. The digital filter has a bandwidth and rolloff curve just as any filter does; the bandwidth can be reduced arbitrarily. The effective noise bandwidth is 0.469/t, where t is the filter length. For example, with a filter length of 4 seconds the equivalent noise bandwidth is 0.12 Hz.

Figures 4-7 and 4-8 are nomographs showing the noise reduction that applies to various filter lengths, given the sensor noise with 2.8 second filtering (diode sensors) or 4.8 second filtering (thermal sensors). These filter times are what diode and thermal sensors have their noise specified at.

The noise power is inversely proportional to the square root of the length. Normally, noise power varies directly with filter bandwidth; but, since power sensors are square law devices (detected voltage is proportional to power), the noise power is proportional to the square root of bandwidth. This can be demonstrated with noise measurements. At very low filter lengths, however, (less than 60 mSec) the noise does not increase without bound for all sensors because the input amplifier noise is restricted with hardware filters to a few Hertz. This additional filtering is not shown in the nomograph.

2. **Error Computation.** Since the noise is Gaussian, both before and after filtering, statistics show what level of confidence factor can be associated with a given reading. (At medium or high power levels the confidence factor is essentially unity.) Figure 4-9 shows a typical set of samples and a typical error band specification of 2 sigma. 95.5% of the readings will fall within ±2 sigma.

Figure 4-10 shows the confidence factor for other error bands. The error band is expressed in pW, no matter what the power level is. (The percentage error band can also be calculated and is shown below.) The RMS noise is taken from the sensor specifications and modified as necessary for filter lengths other than 2.8 seconds (diode sensors) or 4.8 seconds (thermal sensors). Knowing any two of the three parameters (error band, RMS noise and confidence factor), the third can be computed.

As an example, if the sensor RMS noise is 65 pW, and the confidence factor is to be 95.5%, then the error band is 130 pW, single sided (±130 pW). If this were the case, at a measurement level of 1300 pW, the percent error band would be 10% or about ±0.44 dB.

NOTE

The noise specifications given for the thermal sensors is based on the use with the 4312 Thermal Input Module. When the Universal Module is used, the noise is increased by 5 dB.

3. **Noise Error Examples.** Figures 4-11 and 4-12 show the computed error for the 51013 diode sensor at different power levels, for 2.8 and 10 second filters. To achieve these results, the sensor must be at a stable temperature and zeroing must be done immediately before the measurement is taken.

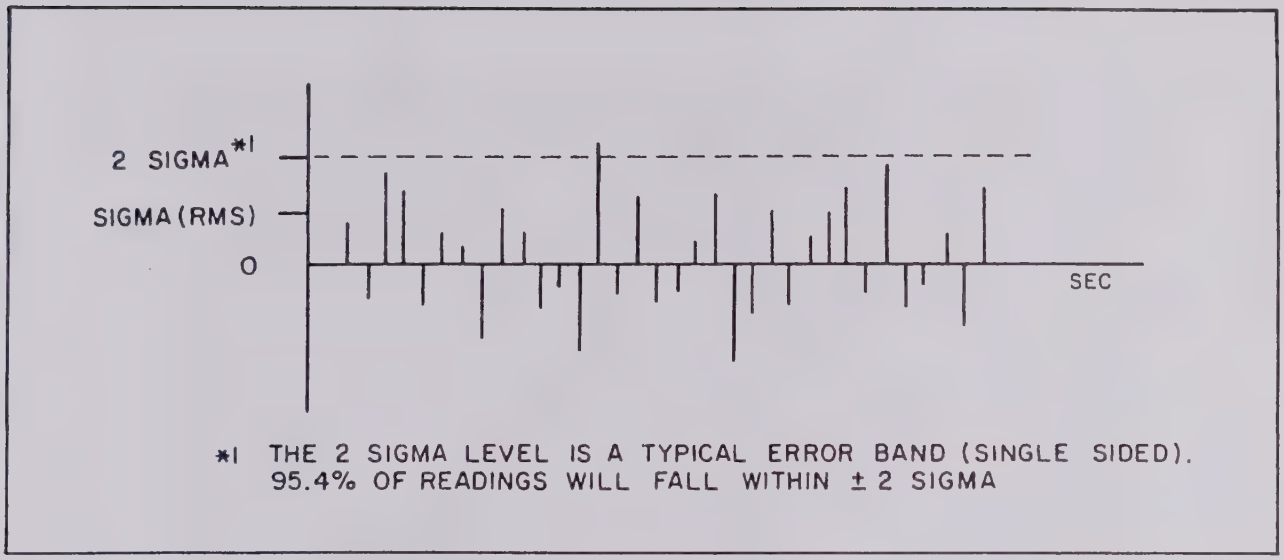

Figure 4-9. Typical Error Band Spec

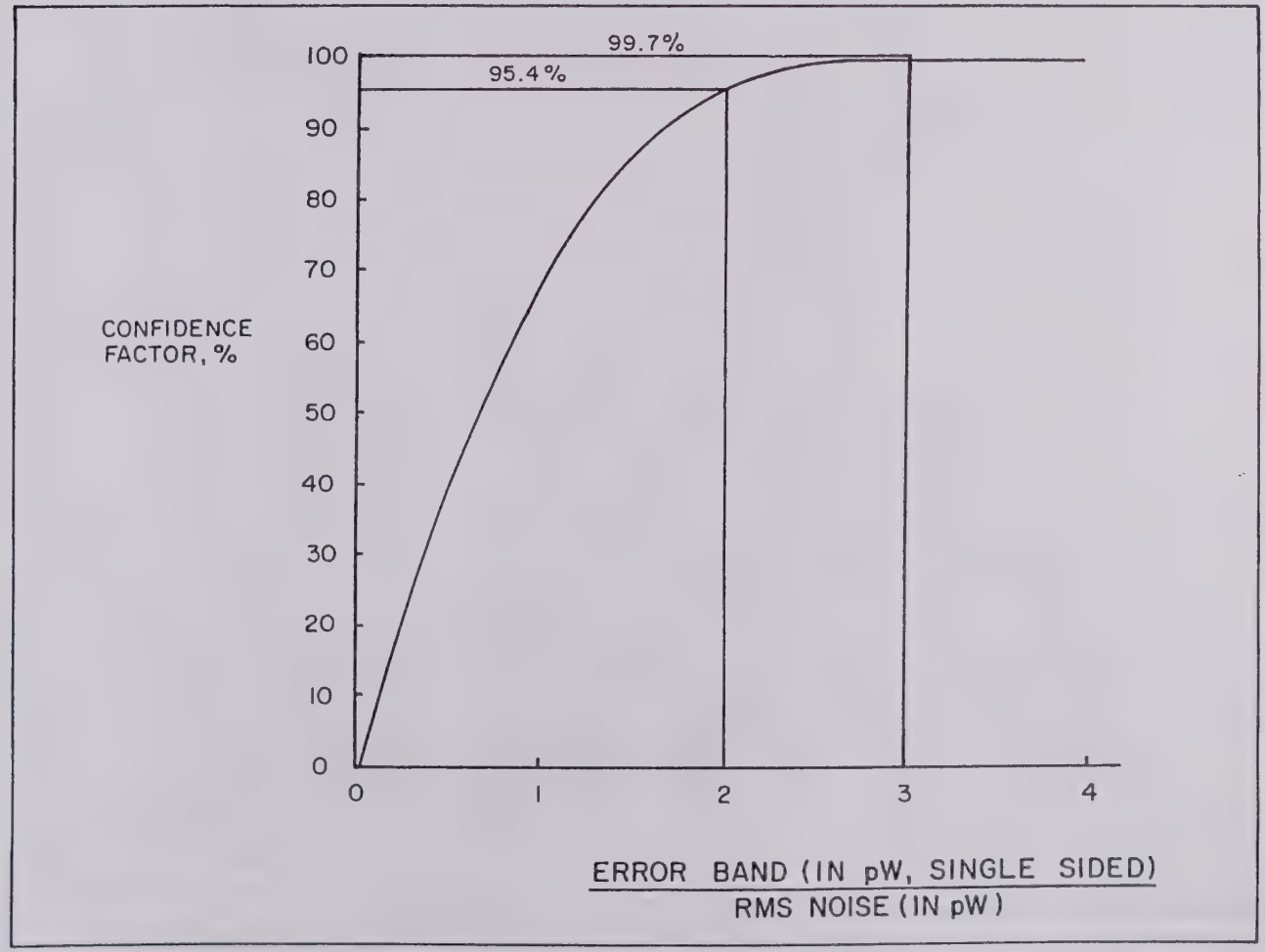

Figure 4-10. Probability of Falling Within an Error Band

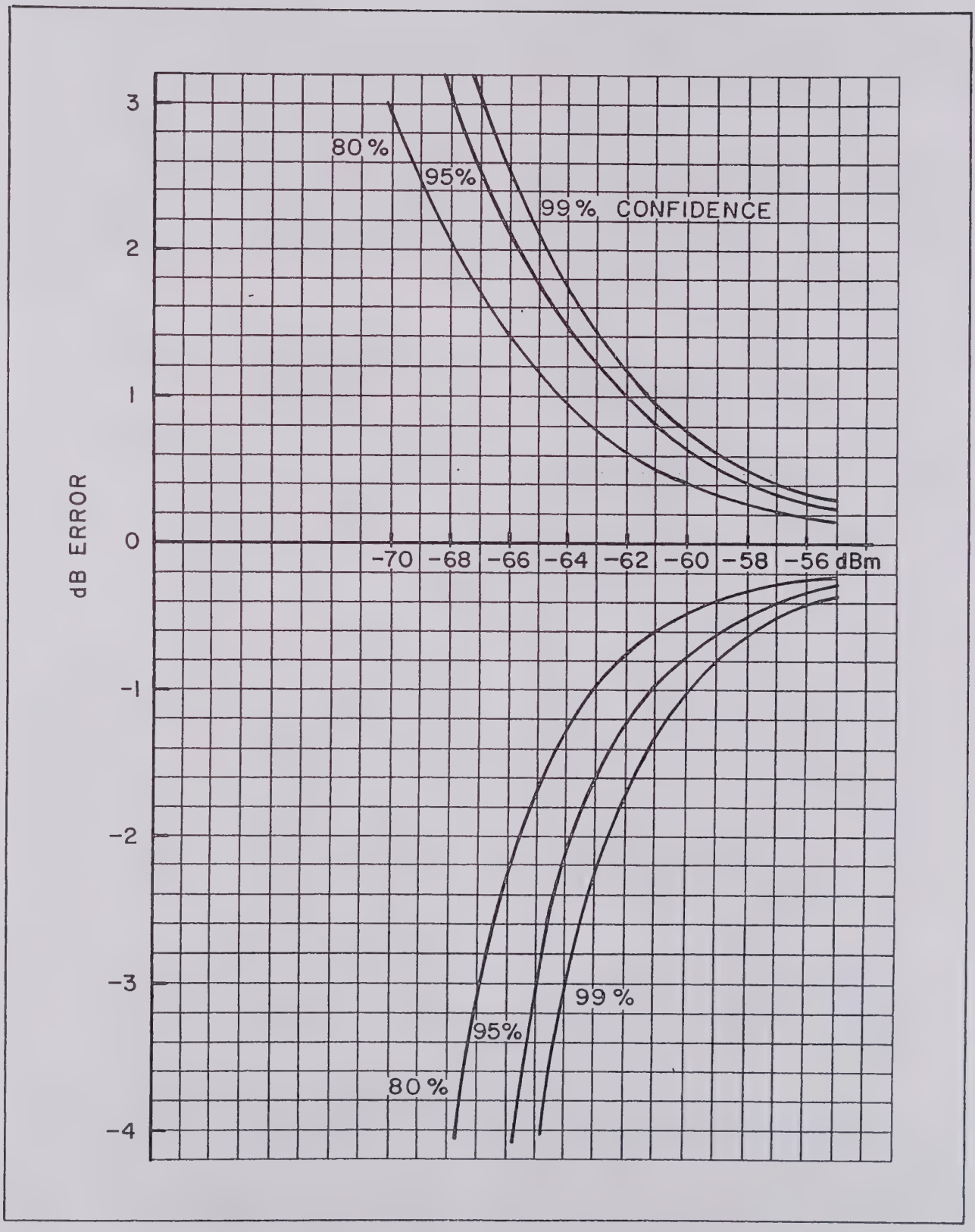

Figure 4-11. 51013 Sensor With 2.8 Second Filter

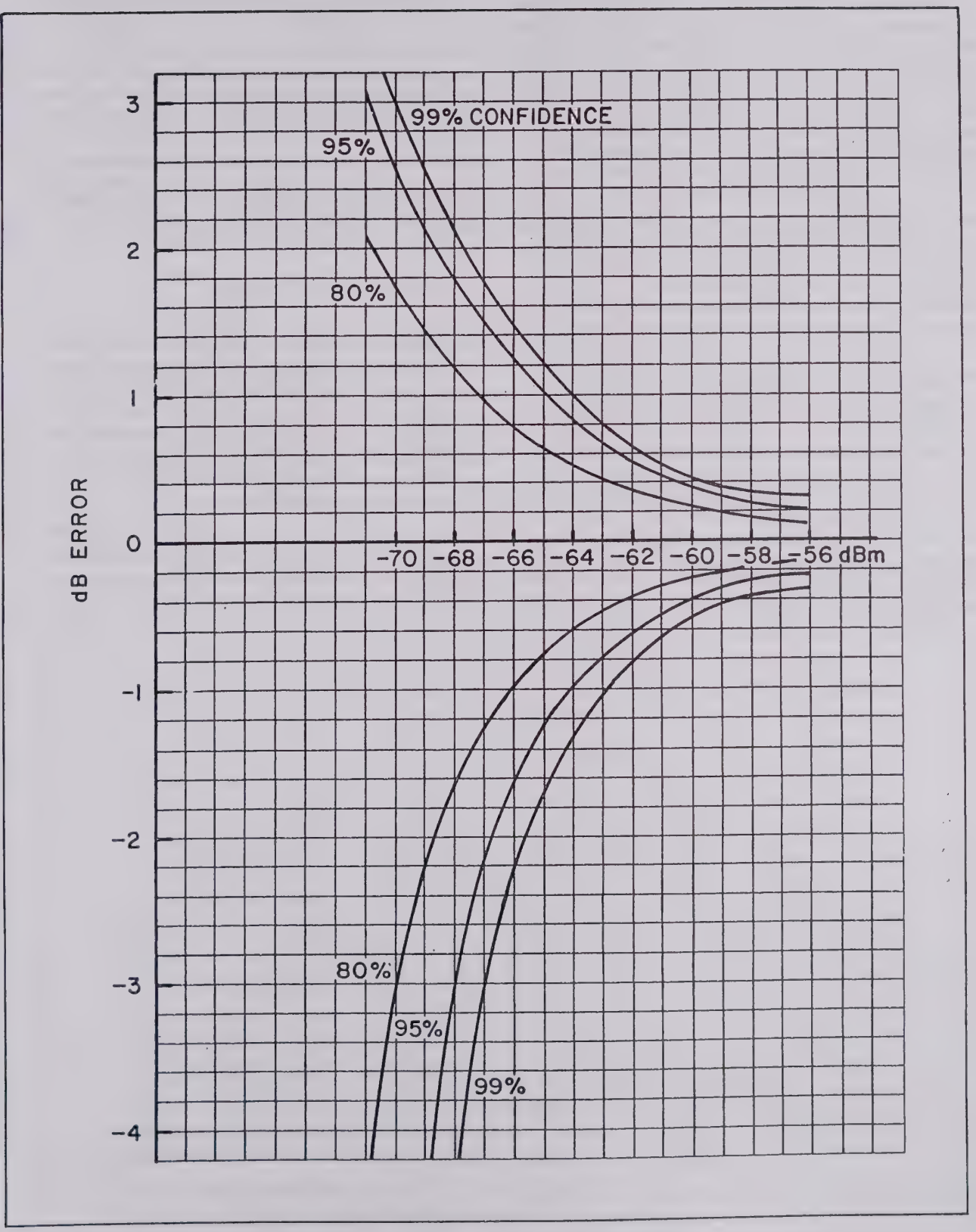

Figure 4-12. 51013 Sensor With 10 Second Filter

4. **Integration of Power.** With long filtering, panel readings may seem erroneous because the filter has not been cleared. For example, with a 20 second filter, if a 2 second RF pulse is applied, the display will indicate a nonzero level for 18 seconds after the pulse has gone away. Additional pulses will be integrated along with the first until, by the process of selective delection, the pulses are removed one at a time from the filter. Actually, measurement samples are deleted, not the pulses, giving rise to a ramping effect at the display/output. This is shown in Figure 4-13. In all senses the filter is a simple integrator. This scheme is not the best if one considers noise rejection versus bandwidth alone, however, bandwidth is not a quantity of direct interest here. For the best compromise of noise rejection and settling time, this method is ideal and has the additional benefit that the output ramp response is easy to interpret, and the display stops abruptly when filtering is complete.

5. **Clearing.** When long filters are used, it may become troublesome at times to wait for the filter to clear. Clearing can be accomplished by changing the filter length to any different value and then resetting it. Alternatively, if the input power is sufficient to keep the unit on range 1 or higher, pressing the zero key will clear the filter since the zero routine begins and ends by clearing, and with a signal input the channel won't actually go through the zero operation. The first method is recommended over the GPIB bus. However, with bus operation most of the trigger modes clear the filter at trigger time; see TRIGGERING.

6. **Partial Results.** The measurement time is affected by the filter since valid readings to within a certain error band can only be obtained when the filter is full. However, in free run mode, if the filter has been cleared, the data is available at reduced accuracy immediately after the first 20 mS sample. That is, the filter uses the number of samples as a divisor when computing the average, and the bus output/display does not ramp but instead "homes in" on the result as the samples accumulate.

4-5. MEASUREMENT TIME.

1. **Step Response.** The measurement time from a power input step is the sum of the overhead time and the length of the digital filter, where the overhead time is defined to be the time delay due to the sensor response time and the measurement software (procesing). The overhead time is given below for certain conditions. The measurement time due to a step response is generally associated with the triggered modes of operation, but apply to free run measurements also.

In theory, the total measurement time is a bit less than the arithmetic sum of the overhead time and the digital filter (it's the convolution of the two) but for most purposes the simple sum will do.

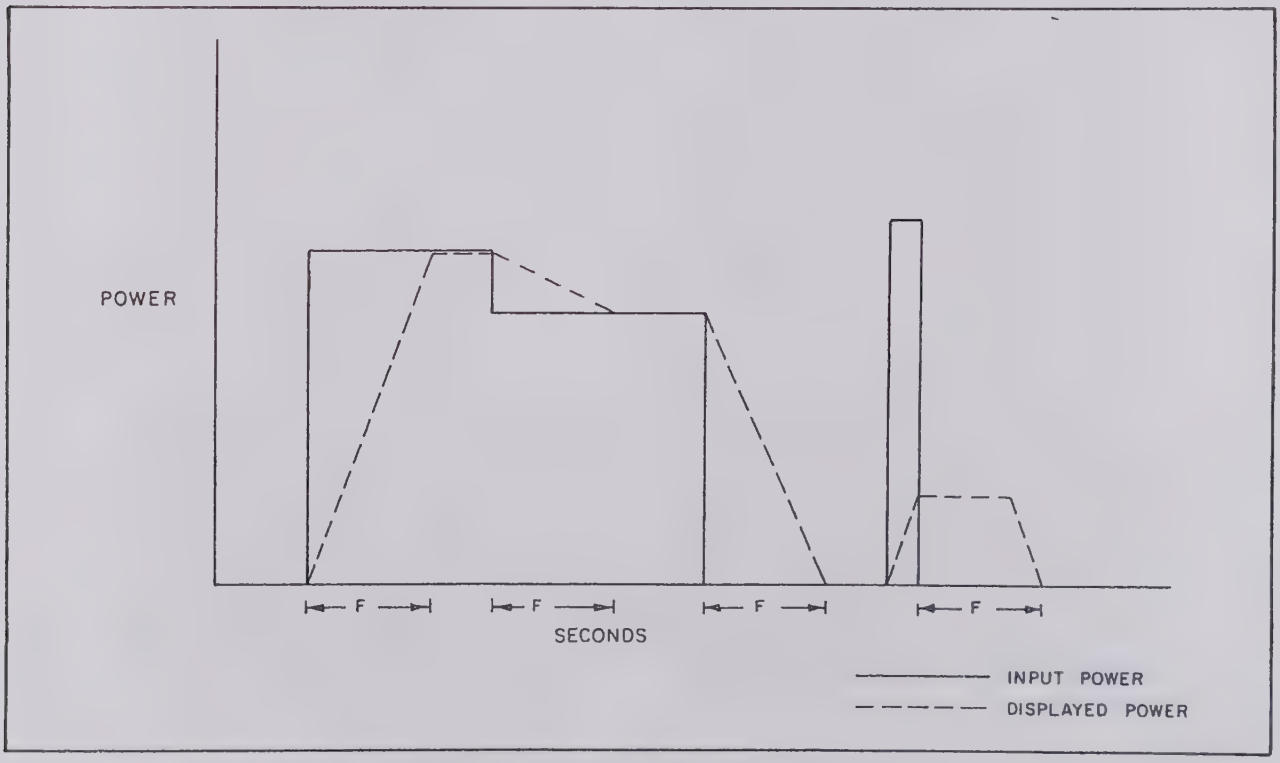

Figure 4-13. Integration of Power

2. **Continuous Response.** Regardless of the overhead time or the digital filter length, the 4300 will output readings at a rate of about 25 mS per channel (30 mS max or 180 mS or six channels) over the bus with the display nonoperating. As the sensor and the digital filter settle, the 4300 readings will ramp up or down at that rate. The continuous time is generally associated with the free run modes of operation (sweeping applications).

3. **Overhead Time.** The overhead time is <200 mS for diode sensors and <450 mS for thermal sensors. This applies for the following conditions:

a. Settling to 99% or .04 dB of the final power.

b. Power step of 10 dB.

c. Range doesn't change (hold range as applicable).

d. Digital filter set to minimum (20 mS, which is a sample of one).

The power step may be upward or downward. Smaller power steps will decrease this time a bit. Larger power steps in the downward direction will increase the time significantly; a 40 dB downward step will take several seconds to settle to .04 dB.

4. **Digital Filter.** The digital filter is a moving average, or pipeline filter which simply integrates the readings over the last x seconds where x is the filter length. In the free run mode (Mode 0), a step input to the filter will produce a linear ramp at the output, terminating when the filter is full. In the triggered mode (Mode 3), the output data is not updated until the filter is full, see "Triggered Operation and Settled Reading" in the section.

5. **Default Filters.** Although any filter length may be chosen from 20 mS to 20 seconds, default filter lengths are programmed in for optimum general conditions, as shown in Table 4-1. Default Filters.

For diode sensors, the range break-points are roughly in 10 dB steps, with the range 0 to 1 breakpoints at about -54 dBm.

For thermal sensors, the break-points are at even 10 dB steps (0, -10, -20, etc.) with the highest point at the top of the sensored specified range.

6. **Settled Reading Measurement Time.** In the settled reading modes (Modes 3 and 5), the output data updates are held off until the measurements have settled. See "Triggered Operation and Settled Reading" in this section. Typical measurement times from a power step to a settled bus measurement are shown in Table 4-2.

4-6. HIGH FREQUENCY ACCURACY.

Power measurements, particularly at high frequencies have a good number of uncertainties which generally arise from imperfect SWR's. If all power sources and

TABLE 4-2. 4300 SETTLING TIME TO 1%

(Free Run Settled Mode)

		End Level dBm							
		+20	+10	0	-10	-20	-30	-40	-50
STARTING LEVEL dBm	+20	—	0.25	0.3	0.35	0.4	0.8	3.5	10
	+10	0.25	—	0.25	0.35	0.4	0.45	1.8	8
	0	0.25	0.3	—	0.3	0.35	0.35	1.1	2.5
	-10	0.3	0.3	0.3	—	0.3	0.35	0.65	1.5
	-20	0.3	0.35	0.3	0.3	—	0.3	0.6	1.2
	-30	0.35	0.35	0.3	0.3	0.3	—	0.5	1.1
	-40	0.4	0.45	0.4	0.4	0.4	0.4	—	1.1
	-50	0.5	0.45	0.45	0.45	0.4	0.4	0.55	—

*Number are in seconds and are typical.

power meters had impedances that were resistive and equal to Zo (the characteristic impedance of the measuring system), most problems would disappear. The incident, dissipated, and maximum available powers would all be equal, and the indicated power would differ only by the inefficiency of the power sensor in converting all of the dissipated power to indicated power. Tuning eliminates most of the SWR effects, but is cumbersome and is seldom done. The use of attenuator pads can mask imperfect SWRs, as can the use of a directional coupler to level the source and reduce its reflection coefficient to a value equal to the directivity factor of the coupler. The 51015 and 51033 sensors have precision built in attenuators which improve the SWR over a straight sensor.

When the complex coefficients of both an imperfect source and a power sensor are not known, but the maximum of actual SWR of both are known, the maximum positive and negative uncertainties of the measured power, Pm, can be determined from Figure 4-14. If the SWR of the source is known to be 1.2 and the SWR of the power sensor is 1.25, we can see that from Figure 4-14 the uncertainty is 2%.

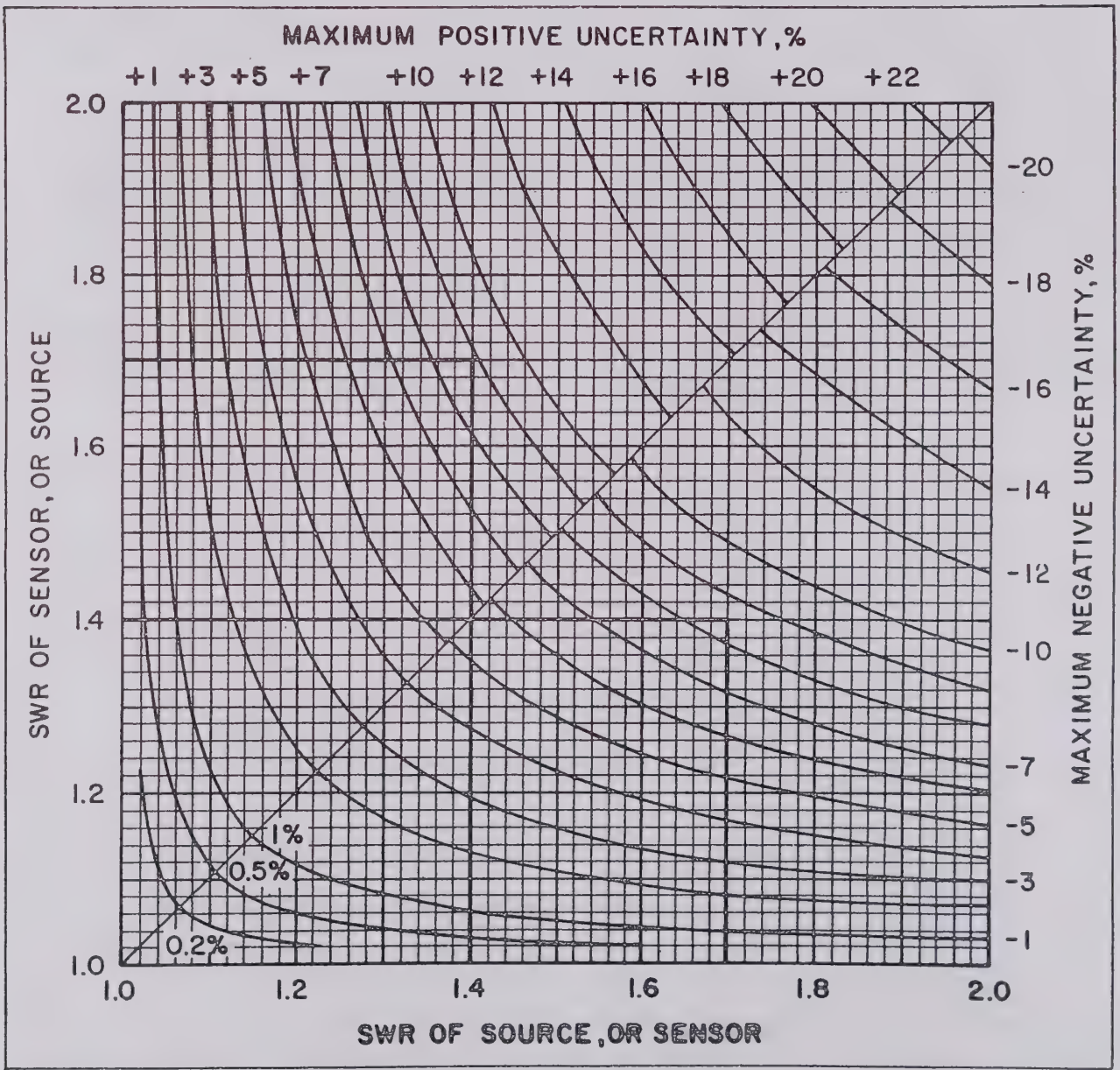

Figure 4-14. Mismatch Uncertainties Chart

4-7. PULSED RF OPERATION.

Although the 4300 is an average resonding power meter, for rectangular pulsed RF if the duty cycle is known, it can be entered and the 4300 will calculate the pulse power (sometimes referred to as peak power; for rectangular envelopes the pulse and peak powers are the same).

The computation is done in the 4300 by dividing the power measurement by the duty cycle. This is valid for thermal sensors or entire range and allows very high pulse powers to be measured. For diode sensors, this technique is valid in the RMS region of the sensor only, however, in the 4300 the RMS region has been extended by 10 dB with software, by taking advantage of the known repeatability of the sensors.

1. **Thermal Sensors.** Figures 4-15 and 4-16 show the regions of valid duty cycle and pulse power that apply to the thermal sensors. As the duty cycle decreases, the average power decreases for a given pulse power and the noise becomes a limitation. Also, there is a pulse power overload limitation, which applies no matter how short the duty cycle is. Lastly, the averge power cannot be exceeded (there is some headroom between the measurement limitation and the burnout level of the sensor).

Since the detection process in thermal sensors is heat, thermal sensors can handle pulse powers that are two orders of magnitude larger than their average power. This makes them ideal for the purpose. Care must be taken not to exceed any of the sensor ratings; see the specifications for more details.

The minimum repetition rate for thermal sensors is 100 Hz, although this is a soft limitation.

2. **Diode Sensors.** Figure 4-17 shows the valid operating region for the 51013 diode sensor. For the 51015 and 50133 sensors, add 10 and 20 dB to the y axis, respectively. As mentioned previously, the operating region has been extended 10 dB above the normal RMS region of the sensor with internal math and correction curves. As with thermal sensors, the bottom end measurement is limited by noise, getting worse as the duty cycle decreases. At the top end, the limitation is on pulse power because even a very short pulse will charge up the detecting capacitors. The error for various duty cycles and pulse powers is shown. As the duty cycle approaches 100%, the error decreases to zero because the 4300 is shaped for CW (continuous wave) RF. The burnout levels must be observed. The burnout level for diode sensors it is the same as for pulsed and CW waveforms.

3. **Duty Cycle Operation.** The procedure for thermal and diode sensors is shown below. Duty cycle may be applied to channels independently, by entering the duty cycle in single channel mode. Then if desired, multichannel may be executed. Of, if all 6 duty cycles are the same, duty cycle can be entered in multichannel mode. The following keystrokes apply:

DTY CY, nn.nn, ENTER

(nn.nn is the duty cycle . . in percent)

In single channel mode, the display indicates average and pulse power and duty cycle. Additionally, with diode sensors, a message indicates what region the sensor is in (RMS, Transition or Peak). The peak region is invalid and this is displayed as an error message. Disabling is accomplished by pressing: DSBL.

TABLE 4-3. CHART RECORDER OPERATION

Parameter Selector	Performs the function
0	Sets the bottom endpoint in dBm corresponding to 0 V (applied in dBm/dBr/dB modes only).
1	Sets the top endpoint in dBm corresponding to 10 V (watts or dBm/dBr/dB modes).
2	Assigns the summation result to one of 6 channels, overriding the normal operation of that channel's output.
3	Turns the chart recorder off.
4	Sets the recorder to indicate when the channel is zeroing.
5	Sets the recorder to indicate when the high or low limits have been exceeded.
6	Sets the recorder to represent the raw data (display still in watts or dBm/dBr/dB).
7	Returns the recorder to measurement mode (takes it out of modes 3, 4, 5, or 6). Used to terminate above entries. See text.

4-8. CHART RECORDER OPERATION.

The chart recorder output on each channel is a DC output from 0 to 10 V proportional to power in the Watts mode and proportional to dB in the dBm and dBr modes. In the dB modes the output can be scaled to span any two endpoints. For example, 0 and 10 V can be set up to correspond to –20 and –15 dBm respectively. In Watts mode, the output is 0 V at zero power and 10 V at a selectable power, entered in dBm. The output impedance

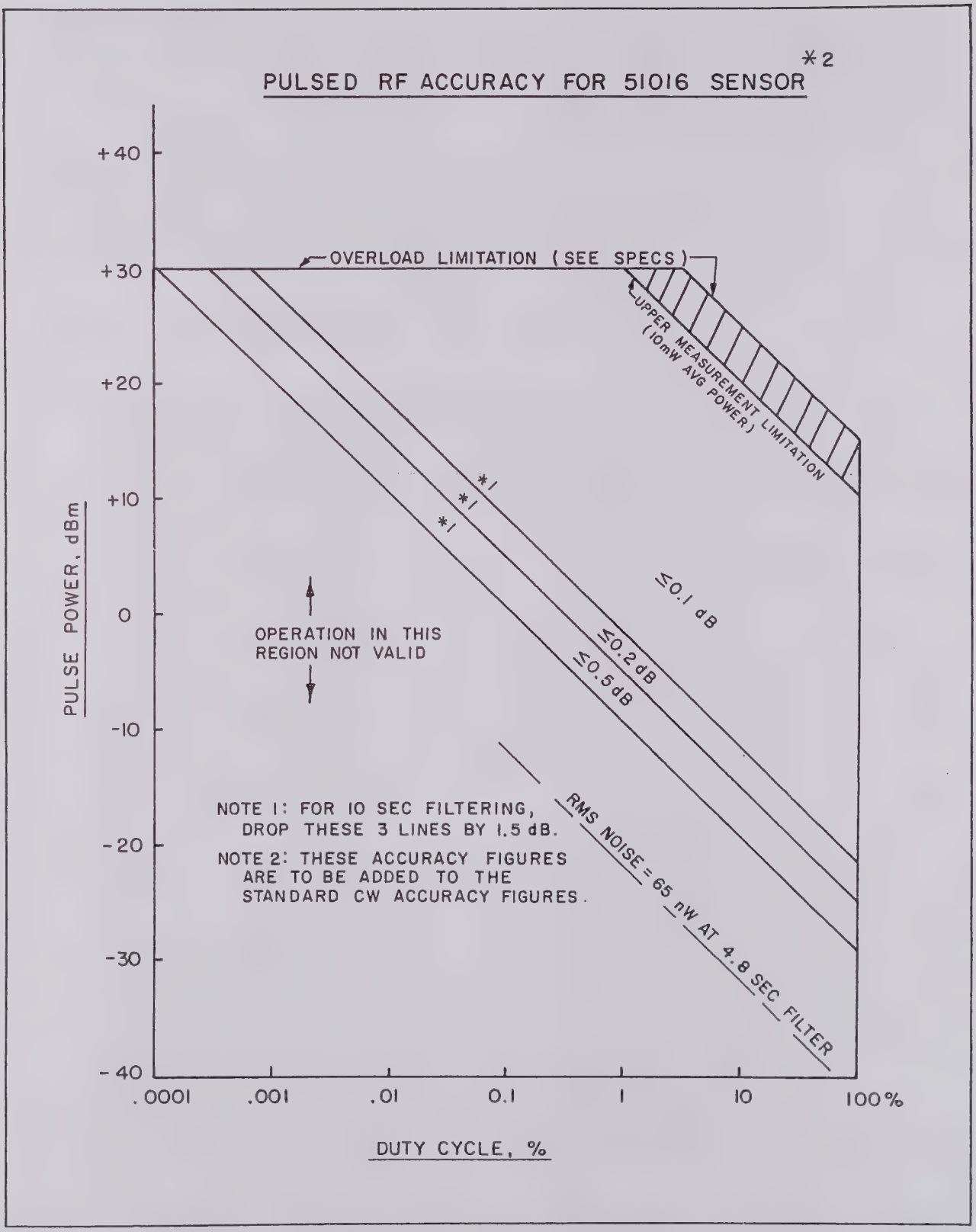

Figure 4-15. Pulsed RF Accuracy for 51016 Sensor

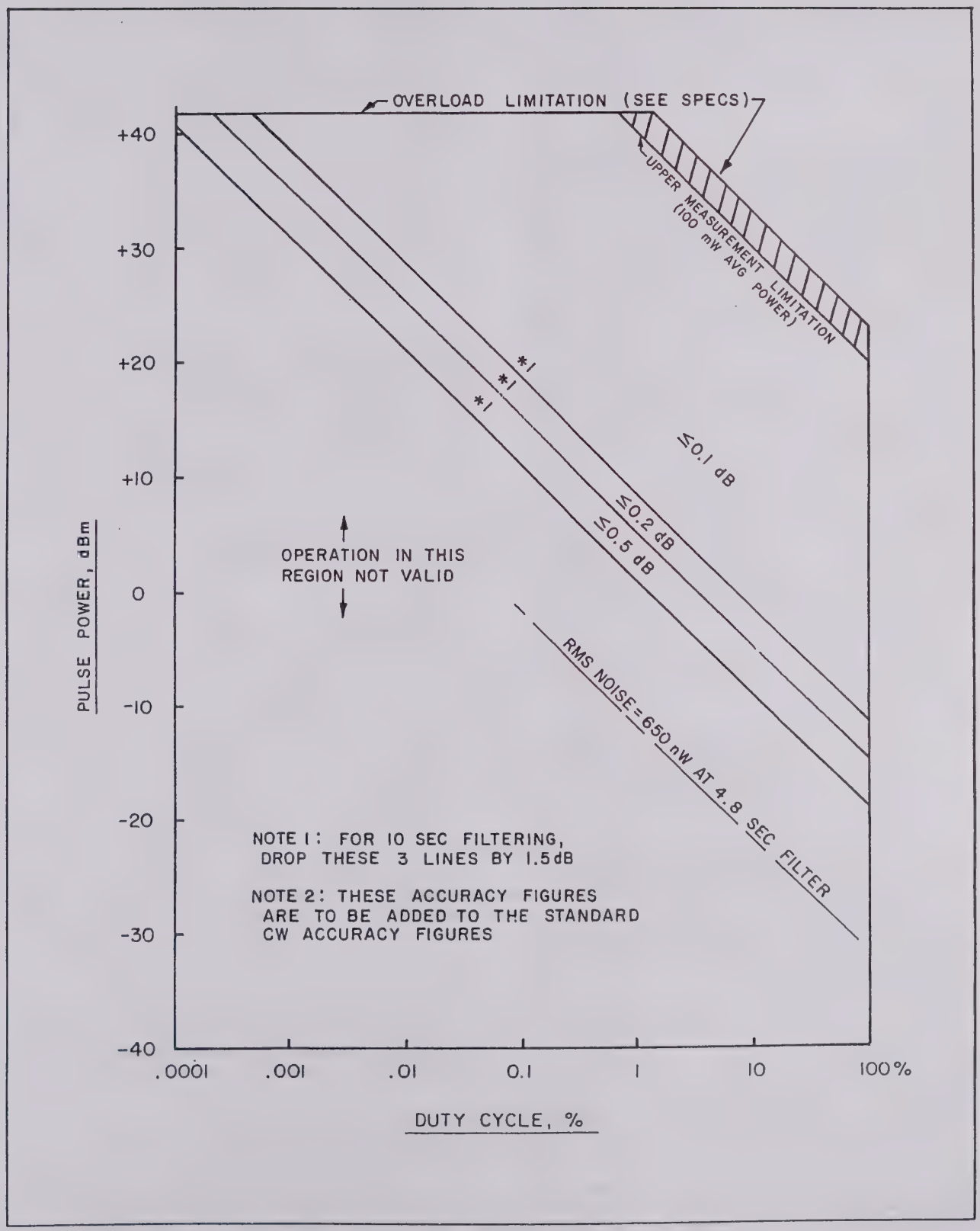

Figure 4-16. Pulsed RF Accuracy for 51017 Sensor

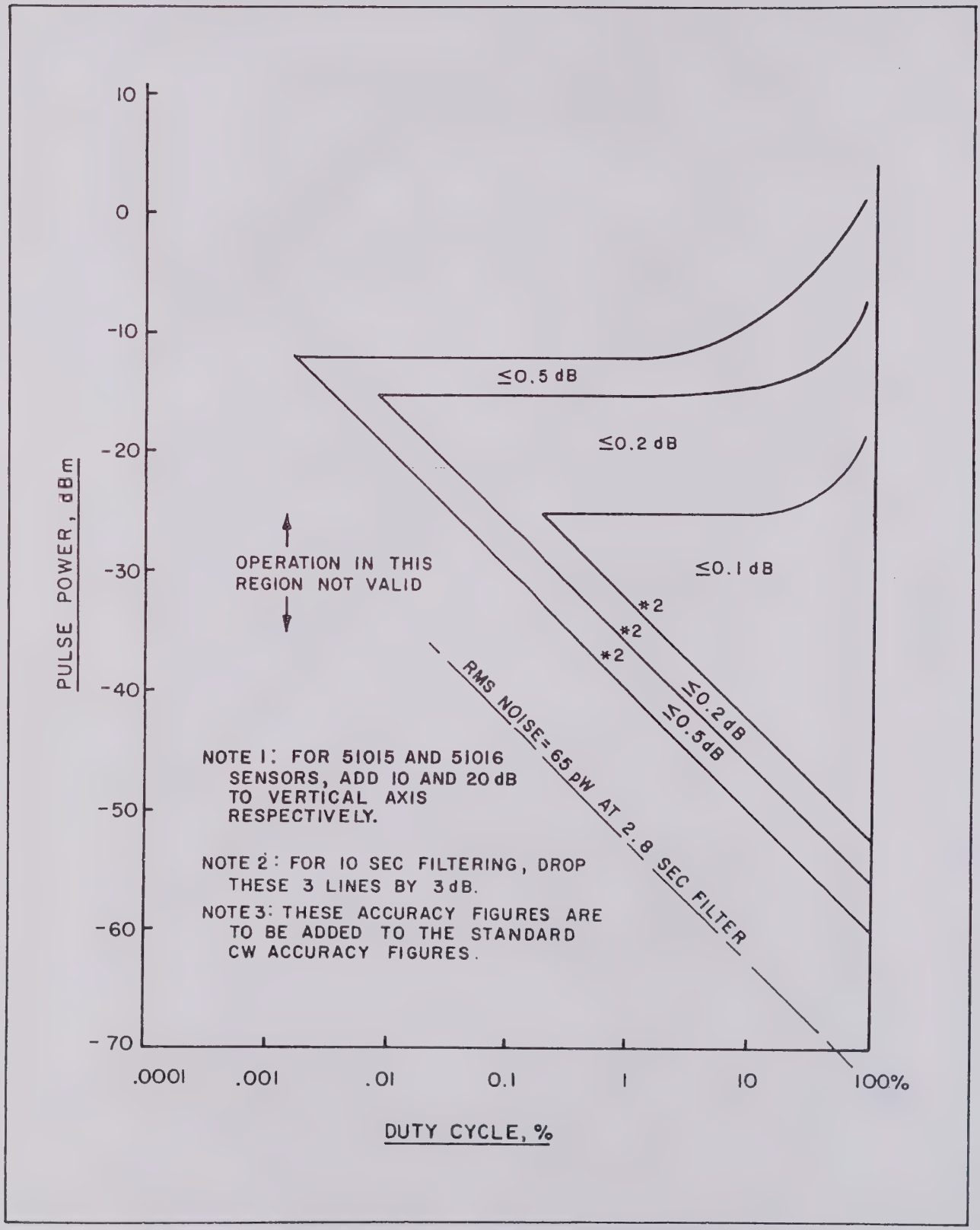

Figure 4-17. Pulsed RF Accuracy for 51013 Diode Sensor

is 9.09k, which gives the user the option of loading it with 1k, thereby reducing the full scale output to 1 V. Resolution is still maintained with this method (the resolution is 12 bits). With a 1M load the circuit is essentially open and the error is small. The displayed power is used as the input to the chart recorder DAC; therefore, all calibration and references appear at the output. The accuracy of the chart recorder is 1% from the power measurement when operated into an open circuit.

Table 4-3 shows a summary of the chart recorder parameter selectors, which are accessed by pressing SPECIAL 2, ENTER. Then the 4300 propmts the user for the parameter selector, after which ENTER is pressed. The recorder operations are described in more detail after the table.

Operations on the chart recorder scaling affect all displayed channels, whether in single or multichannel mode. All channels are independent. If the scaling on one channel is set, then the 4300 can put in multichannel and the scaling for that channel will remain the same.

When an instrument initialization is done (RECALL 0), the chart recorder scaling is returned to a default condition. See the "RECALL" key description.

1. **dBm/dBr Mode Setup.** The top and bottom endpoints representing 10 and 0 V are entered with the following procedure.

a. First select the channel desired (single channel mode) or multichannel, then press the following keys:

SPECIAL, 2, ENTER
0, ENTER
Desired bottom point in dBm
ENTER
SPECIAL, 2, ENTER
1, ENTER
Desired top point in dBm
ENTER

b. If the last parameter selector used was either 3, 4, 5 or 6, the additional step has to be performed (this re-institutes the measurement mode):

SPECIAL, 2, ENTER
7 ENTER

2. **WATTS Mode Setup.** The top endpoint is entered in dBm (the 4300 can be in Watts mode but the entry is always interpreted in dBm). The bottom end power corresponding to 0 V is always zero watts. The procedure is as follows:

a. First select the channel desired (single channel mode) or multichannel, then press the following keys:

SPECIAL, 2, ENTER
1, ENTER
Desired top end point in dBm
ENTER

b. If the last parameter selector used was either 3, 4, 5 or 6, the additional step has to be performed (this re-institutes the measurement mode):

SPECIAL, 2, ENTER
7 ENTER

3. **Summation Setup.** In summation mode, any one of the 6 recorder outputs can be assigned to represent the sum/difference of up to 6 channels in dB. This is useful for subtracting out the generator level (normalizing the plot). The channel whose chart recorder outputs the result does not need to be any of the channels that is used in the summation. For example, the channel 6 chart recorder can be used to show the difference between channels 1 and 2. The summed chart recorder function works in dBm mode only.

The example below shows how to set up a gain measurement, channel 1 minus channel 2, to span 15 to 25 dB (0 V is a gain of 15 dB and 10 V is a gain of 25 dB). The output is to be assigned to channel 4. Note: the scaling on channels 1 and 2 are not significant for this example. The scaling is that of the channel that is assigned to the sum. However, they can be set up normally as shown in previous sections (see dBm mode) and they will function independently.

a. First enter the summation equation "1-2" with the summation key. Then press the following keys:

SHIFT
SET CH, 4, ENTER
SPECIAL, 2, ENTER
0, ENTER
15, ENTER (sets scaling on channel 4)
SPECIAL, 2, ENTER
1, ENTER
25, ENTER

SPECIAL, 2, ENTER
2, ENTER (assigns sum to channel 4)
4, ENTER

E ENA (enables sum mode)

b. If the last parameter selector used was either 3, 4, 5 or 6, the additional step has to be performed (this re-institutes the measurement mode).

SPECIAL, 2, ENTER
7 ENTER

Channel 1 would be connected to the output of the device under test and channel 2 would be connected to the generator tap. Note that the scaling and measurement modes are set up in single channel mode.

4. **Recorder Output OFF.** When the recorder output is not being used, disabling it will increase the processing throughout on the GPIB by 1 or 2 mSec per channel because the scaling operation is bypassed in the micro-

processor. This is accomplished with the procedure below.

a. First select the channel desired (single channel mode) or multichannel, then press the following keys:

SPECIAL, 2, ENTER
3, ENTER

b. Turning the recorder back on is accomplished by going back to measurement mode (see below).

5. **Zero Indicator.** The chart recorder can be used to indicate when the channel is being zeroed for purposes of turning off the signal source. The recorder output will go to a logic 0 when the zero key is pressed. The zeroing operation does not begin for 2 seconds after the key is pressed giving the generator and sensor time to decay. Setting up this mode is done as follows:

a. First select the channel desired (single channel mode) or multichannel, then press the following keys:

SPECIAL, 2, ENTER
4, ENTER

b. To disable this mode, go back to measurement mode (see below).

6. **Limit Indicator.** The channel output can be used as a go/no-go limit indicator (high and low limits set by the front panel) with the following procedure. It is assumed that the high and low limit values have been set up on the channel before going into the chart recorder mode:

a. First select the channel desired (single channel mode) or multichannel, then press the following keys:

SPECIAL, 2, ENTER
5, ENTER

b. To disable this mode, go back to measurement mode (see below).

7. **Raw Value.** The recorder output can be put in a mode where its output represents the raw unprocessed A/D vlaue (unshaped and uncalibrated) as follows:

a. First select the channel desired (single channel mode) or multichannel, then press the following keys:

SPECIAL, 2, ENTER
6, ENTER

b. To disable this mode, go back to measurement mode (see below).

NOTE

When the 4300 is displaying in raw value mode, the chart recorder automatically represents the raw value. This mode is provided for the case when the display is showing watts or dBm, and the chart recorder still represents raw value.

8. **Measurement Mode.** When parameter selectors 3, 4, 5 or 6 have been executed and it is desired to disable these and return to measurement mode, the following procedure should be performed:

a. First select the channel desired (single channel mode) or multichannel, then press the following keys:

SPECIAL, 2, ENTER
7, ENTER

4-9. TRIGGERED OPERATION AND SETTLED READING

The 4300 has five modes of "triggering". Three of these are internally triggered and are not "triggered" per se, but are included here for completeness. The five modes are accessed by pressing SPECIAL, 1, ENTER, and the number 0 to 4 as shown below. Each channel can be in a different trigger mode. This can be useful, for example, when "triggered settled" readings are required on channels 1 and 2, but channels 3 and 4 are not to hold up the 1 and 2 channel readings because of an unsettled condition. (In multichannel mode, in order to get a 6 channel reading, all channels that are set to the settled reading mode must be settled.) In all of the filtered and settled modes, an SRQ is available when the reading is filtered/settled. See the GPIB Section for more details. The modes are:

1. **MODE 0, FREE RUN.** The free run modes are internally triggered; the channels run continuously and asynchronously, taking samples every 20 mS. The display and bus are updated continuously in both single and multichannel modes. Sensor readings are put into the digital pipeline filter and "taken out" at the other end. Thus complete settling of the bus/display is delayed from step power inputs by an amount roughly equal to the digital filter length in milliseconds plus 200 mS. However, the pipeline outputs are still available while the digital filter is ramping up/down due to the power step. If the power step is large enough to cause a range change, the digital filter contents are dumped, but data is still available at reduced accuracy (partially filtered according to how many samples have been taken). The filter "homes in" on the reading as samples accumulate in this mode. See the discussion on filtering and also "Measurement Times" in this section for more information.

2. **MODE 1, FREE RUN FILTERED.** This mode is also internally triggered at a 20 mS rate. In the case of a range change, the digital filter contents are dumped and responses on the bus and display are held off until the digital filter is full. In this way, readings are guaranteed to be filtered. A multichannel reading will not be returned on the bus until all channels that are in this mode are filtered. The display is blanked during periods of filling up, but this is done on a channel by channel basis. In multichannel mode, each channel will generally fill its

filter at a different time, since the default filters are range dependent. If the filter length is set by the operator, however, this length applies to all ranges. All channels would normally be set to the same length in this mode (set the filter length in multichannel mode), because then the readings will all be available at the same time.

3. **MODE 2, FREE RUN SETTLED.** This mode is also internally triggered. Responses on the bus and display are held off until the measurements are settled (settled is based on measurements and is determined by an algorithm described below). In this way, readings are guaranteed to be settled, freeing the host computer of this job. A multichannel reading will not be returned on the bus until all channels that are in this mode are settled. The display is blanked during settling, but this is done on a channel by channel basis. In multichannel mode, each channel will alternate between settled and unsettled independently (on the display) as their powers change. The channel is declared settled when the slew rate is less than .04 dB per second, approximately. This corresponds to settling to 99%. By definition, the digital filter must be full to declare a channel settled. At low power levels, the sensor noise is greater than .04 dB second to second, and in order to provide settled capability at these levels, the acceptable settled window is opened up automatically. The Settled modes operate by comparing the last half of the digital filter to the first halt (old readings to the most recent); therefore a power step in the Free Run Settled Mode will not be reflected as an unsettled reading until a significant number of the new measurements are loaded into the filter. The Triggered Settled Mode reacts immediately in this case.

4. **MODE 3, TRIGGERED FILTERED.** In this mode, all the displayed channels are triggered over the bus, or from the front panel using SPECIAL, 9, ENTER. In multichannel mode, if it is desired to trigger just one channel, the instrument can be put in single channel mode temporarily, then the trigger can be sent. Going back to multichannel mode can be done before the channel digital filter has filled up. Channels must be in Mode 3 or 4 to react to a trigger. When a trigger is received, the channel(s) first wait for the trigger delay time (defaulted to 130 mS, but can be set, see Delayed Trigger below). Then the digital filter contents are dumped and responses on the bus and display are held off until the filter is full. In this way, readings are guaranteed to be filtered. A multichannel reading will not be returned on the bus until all channels that are in this mode are filtered. The display is blanked during periods of filling up, but this is done on a channel by channel basis. In multichannel mode, each channel will generally fill its filter at a different time, since the default filters are range dependent. See the comments for Mode 1 regarding this.

5. **MODE 4, TRIGGERED SETTLED.** In this mode, all the displayed channels are triggered over the bus, or from the front panel using SPECIAL, 9, ENTER. In multichannel mode, if it is desired to trigger just one channel, the instrument can be put in single channel mode temporarily, then the trigger can be sent. Going back to multichannel mode can be done before the channel digital filter has filled up. Channels must be in Mode 3 or 4 to react to a trigger. When a trigger is received, the channel(s) first wait for the trigger delay time (defaulted to 130 mS, but can be set, see Delayed Trigger below). Then the digital filter contents are dumped and responses on the bus and display are held off until the readings are settled. See Free Settled Mode for a definition of settled. In this way, readings are guaranteed to be settled. A multichannel reading will not be returned on the bus until all channels that are in this mode are settled. The display is blanked during the settling period, but this is done on a channel by channel basis. In multichannel mode, each channel will settle at a different time, because of different power levels.

6. **MODE 5, TRIGGER DELAY.** This is not a trigger mode per se, but a parameter that is set on a channel by channel basis. (Entry of the delay can be in multichannel if it is desired to have the same delay on all channels). The trigger delay is set in 10 mS increments from 40 mS to 5000 mS. The default time is 130 mS and is set with RECALL 0 or a general instrument reset from the rear panel switch. When triggered, a channel will take measurements immediately but will discard them until the trigger delay is exhausted. Then it will begin entering them into the digital filter. In this way, the channel(s) will get to the correct range even if the power step has been large, but the slewing of the sensor/source will not be integrated into the reading. This also provides a means to trigger the source and the 4300 at the same time, when it is known what the generator delay is. The default time of 130 mS is enough time for a 6 dB power step to be read correctly to 99% of settling for the diode sensors. For large power steps, refer to the section on measurement times for typical total measurement time.

4-10. WAVEFORM SENSITIVITY

The thermal sensors are insensitive to the waveform since they average RF power over many tens of milliseconds. Modulation, non-sinusoidal waveforms, and even pulses can be detected without distortion of the measurement. They are referred to as TRMS responding.

Diode sensors are also TRMS responding below about -20 dBm (-10 and 0 dBm for the attenuated versions 51015 and 51033). This is because: 1) the sensors are dual diode types, and 2) diodes themselves respond in a square law fashion at low and medium levels. This is not

an approximation but rather an inherent effect. This is because the diodes do not turn on and off as switches, but rather behave as signal dependent resistors. Even with no signal input, the diodes have a finite conductance, and the conductance gets modulated on a cycle by cycle basis to give a net DC offset proportional to the power.

The square law response can be seen in Figure 4-18 where a 100% AM modulated signal is shown to have virtually no effect on the measured power, at low levels. Of course, FM and PM can be measured, at any level, since the envelope of these modulated signals is flat just like CW. Frequency shift keyed (FSK) and Quadrature modulation also have flat envelopes and can be measured at any power level.

At higher power levels (above -10 dBm approximately for the 51013 sensor), the diodes operate as peak detectors. The 4300 is software calibrated to calculate the RF power based on a shaping transfer function (RF to DC) for each sensor type. However, only CW signals are valid in this region, and also in the "transition" region from -20 to -10 dBm ("CW" here refers to flat envelope waveforms such as FM, PM, etc.). Rather than discard this region as unuable, the 4300 offers it as a CW only mode.

Pulsed RF waveforms can be measured also, with either the thermal sensors or the diode sensors. The 4300 will calculate the pulse power based on the duty cycle; see "Pulsed Operation" in this section

Pulsed DC can be measured, even with DC offsets, with thermal sensors and to a limited extent with the diode sensors (the limitation is to stay in the TRMS region). The repetition rate for pulsed DC should be higher than about 300 Hz for the diode sensors, otherwise the sensor begins to ride on the signal (the sensor responds to each dip and peak). The 51051 sensor is somewhat faster and requires a minimum repetition rate above 10 KHz or so.

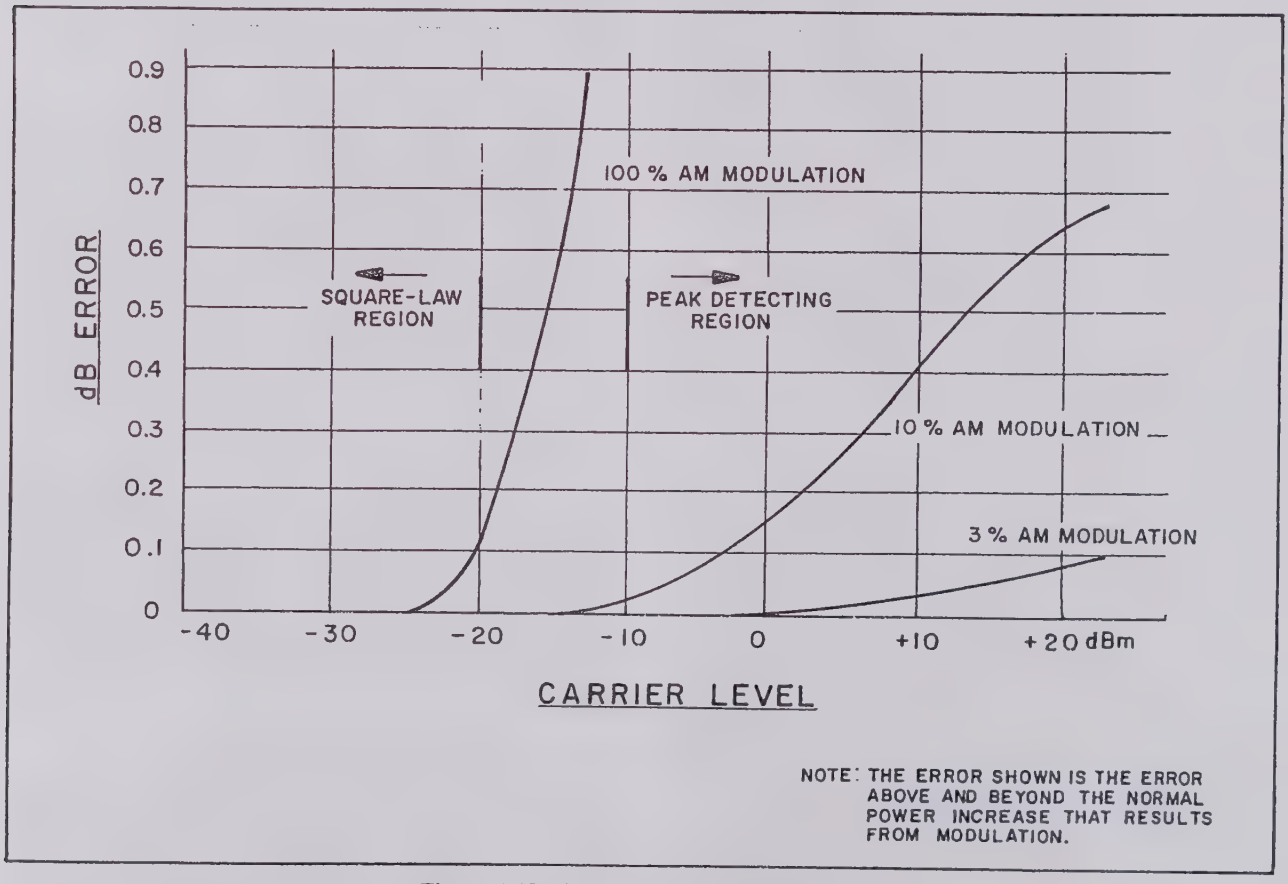

Figure 4-18. Error Due to AM Modulation
(Diode Sensor 51013)

SECTION 5
THEORY

5-1. INTRODUCTION.

This section contains information on the theory of operation of the 4300, including circuit descriptions. Refer to the Overall Block Diagram, Figure 5-1.

The input channels are modular and field installable. The sensor inputs to the channels is a DC voltage from about 1 microvolt to about 3 volts, differential. The input channels digitize this and perform the digital filtering function, and triggering. The data, referred to as the Raw Value, is presented to the control board via the bus board at 20 mS intervals asychronously. The control board performs shaping and calibration on each channel's data, and handles all processing functions such as high frequency correction, sensor data manipulation, and autocalibration. The control board also performs the bus operations and writes to the display and reads the keyboard.

The 30 MHz calibrator, if installed, is controlled by the control board via the 30 MHz digital board. This digital board has an EEPROM which stores the calibration data for the calibrator.

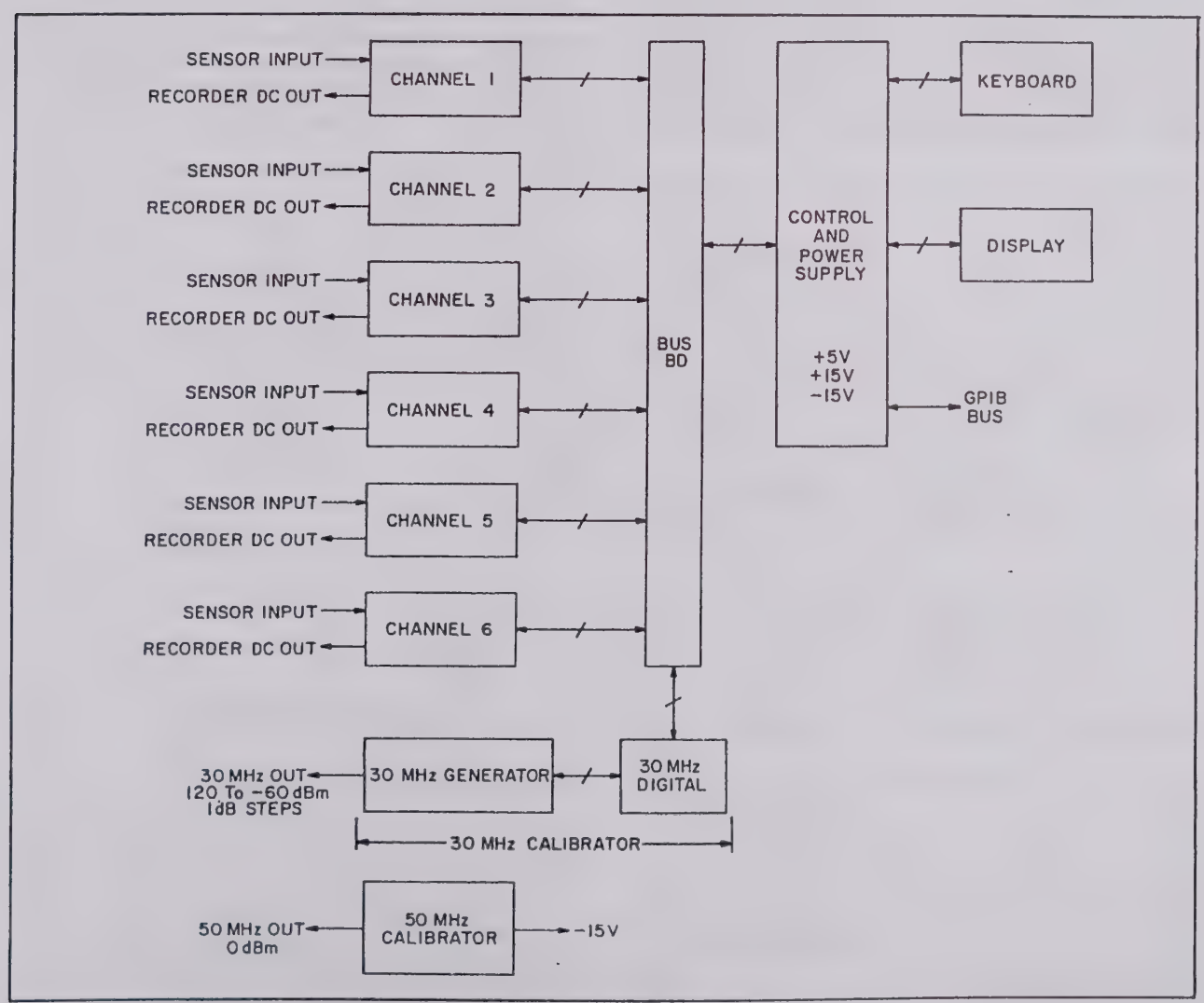

Figure 5-1. Overall Block Diagram

The 50 MHz calibrator, if installed, is fixed at 0 dBm and has no output control. Either calibrator may be installed with their outputs at the front or rear of the instrument.

The sections below describe each of the blocks in more detail.

5-2. SENSORS.

1. **Diode Sensors.** Diode sensors consists of a pair of non-inductive 100 ohm resistors wired in parallel resulting in a precision 50 ohm load impedance. The RF voltage developed across the load resistor is coupled to the diodes by a DC blocking capacitor. The RF voltage is rectified by the diodes to produce a differential DC voltage. At powers below approximately -20 dBm (for sensors without attenuators such as 51013), the DC voltage is linearly proportional to power. Operation is in the square law region of the diode. The linearity is preserved over many decades of power. Above approximately -10 dBm, the DC voltage is proportional to power squared. To linearize the sensor response above -10 dBm, the microprocessor calculates power based on shaping data stored in memory. Other resistors and capacitors are used in the DC path to optimize the sensor's characteristics.

2. **Thermal Sensors.** Thermal sensors use a thin film bimetallic resistor both as an RF load and also as a thermocouple. Sensitivities are on the order of 500 microvolts per milliwatt of RF power. Their output impedance is low, so bipolar op amps can be used on the thermal input channel.

5-3. INPUT CHANNELS.

1. **General.** Refer to Figure 5-2. The RF power to be measured is applied to a sensor which converts RF power to a proportional DC voltage. The magnitude of the sensor DC voltage output can vary from microvolts to volts, as a function of the power level to the sensor. Since the analog-to-digital conversion process has a relatively small dynamic range of 10:1, a variable gain instrumentation amplifier is used to scale the voltage applied to the converter. To reduce the undesirable effects of the amplification process (i.e., drift, DC offset, and 1/f noise), the DC voltage from the sensor is first converted to an AC square wave by the chopper.

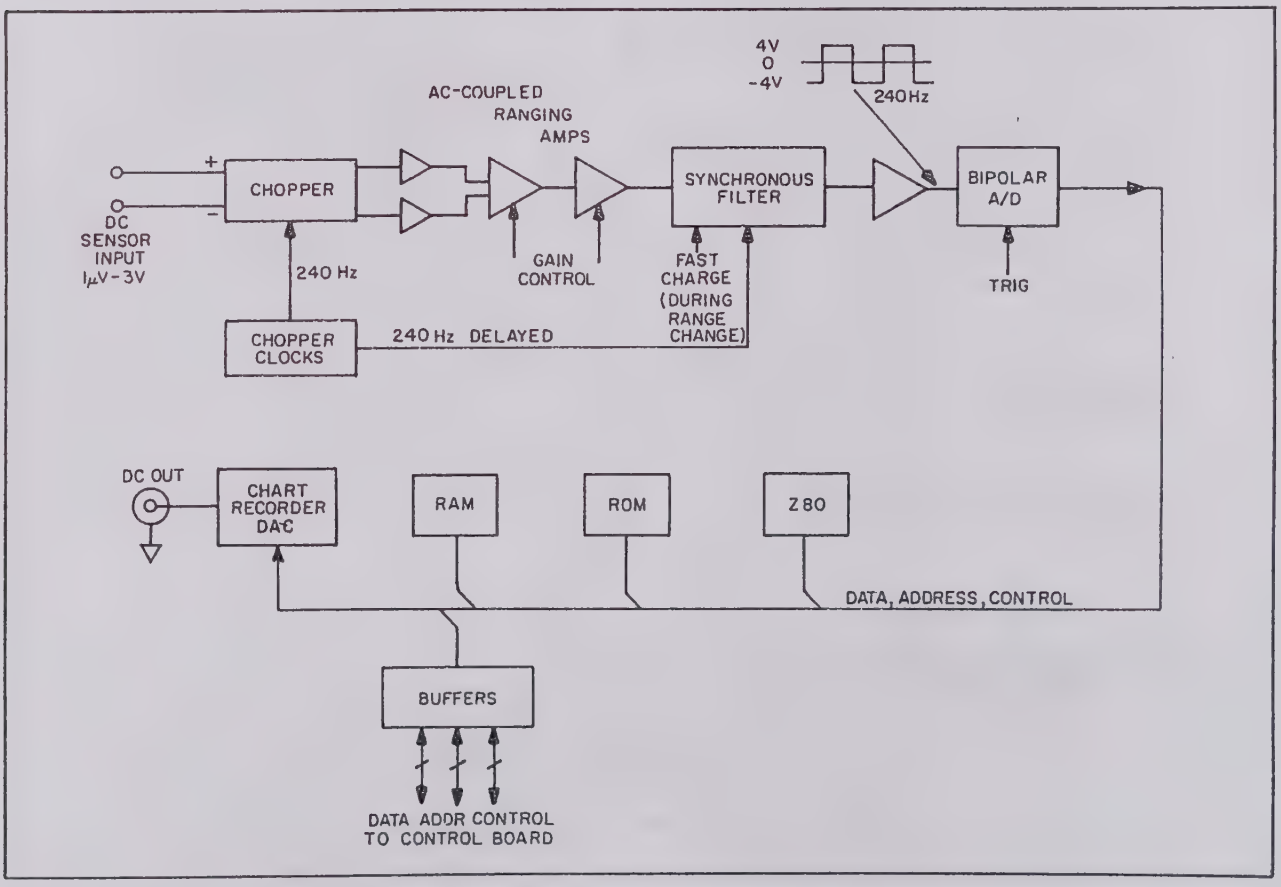

Figure 5-2. Input Board Block Diagram

2. **Chopper Circuits.** The chopper contains an integrated circuit, U1, which contains four solid-state switches. These four switches convert the differential DC voltage of the sensor to a square wave AC signal. The switches are sequenced by chopper drive signals generated by a frequency divider chain. Potentiometers R1 and R2 provide means for cancelling capacitively coupled chopper drive transients thereby adjusting the chopper output for an overall DC offset of less than 1 microvolt. The chopping cycle is synchronized to AC power line frequency. Any interferring signal in synchronization with the power line will occur in synchronization with the chopper. In this way errors originating from the power line can be corrected when the instrument is zeroed. The chopper circuitry is driven by a symmetrical square wave from the chopper drive circuitry.

3. **Amplifier Circuits.** The balanced AC square wave signal from the chopper is amplified by the precision instrumentation-type input amplifier. The gain of operational amplifiers AR1 and AR2 is controlled by the microprocessor through range latch U17, multiplexer switch U10, and associated feedback resistors. The AC output from AR1 and AR2 is applied to the differential inputs of AR6a which converts the signal from balanced to single-ended. This signal is next amplified by AR6b, multiplexer U14 and associated feedback resistors. The gain of this amplifier is also controlled by the microprocessor through range latch U17. The gains for the two amplifiers, the DC calibration values, and the resulting A/D count are tabulated on Table 5-1. The DC calibration is based on the Boonton 2500 or 2510 calibrators.

TABLE 5-1.

Range	DC Calibration Input 90% of full-scale	Amp. 1 gain	Amp. 2 gain	Nominal A/D Input
0	9 μv	502	165	0.5 V peak
1	90 μv	502	66	2.0
2	900 μv	100	66	4.0
3	9 mV	10	66	4.0
4	90 mV	1	66	4.0
5	900 mV	1	6.6	4.0
6B	4.5 V	1	1	3.0

4. **Filter and A/D Circuits.** The synchronous bandpass filter consists of R31, C16, C17, U13 and AR3. The filter is used to condition the AC square wave signal prior to the A/D conversion. The filter is a simple resistor capacitor network which alternately switches between R31-C16 and R31-C17. The multiplexer switches U13a and U13b are driven synchronously with the chopper drive signal thereby keeping the positive half cycle and the negative half cycle directed to their respective capacitors. The RC time constant is several chop cycles long. Operational amplifier AR3 provides high impedance buffering between the filter and the A/D. Switch U13c reduces the time constant of the filter momentarily when ranging to allow faster charging. This switch is also closed momentarily when the instrument is triggered.

The A/D U20 is synchronized to the chopper AC square wave and takes a sample about half way through a half chopper cycle. The A/D measures the magnitude of the AC square wave at the output of AR3 with respect to ground on both half cycles of the waveform and passes the resulting binary value to the microprocessor. A signal of approximately ±4.5 V (9 V p-p) will cause the channel to increment range to the next higher value. On alternate chopper cycles, a voltage approximating ½ LSB of the A/D is added into the signal via R44. When two or more measurements are averaged in software, an effective A/D resolution of 13 bits is achieved. (A measurement consists of two A/D, one each performed during half of the chopper period.) Integrated circuit U19 is a precision 5 volt voltage reference for the A/D. CR4 and CR5 provide input protection for U20.

Integrated circuit U21 is a 12-bit D/A converter. Along with AR5 it provides a 0 to 10 volt DC signal to the recorder output. The control board microprocessor calculates the recorder output voltage from parameters set by the instrument user. The voltage is proportional to power or dBm. A 12 bit digital word representing the output voltage is sent from the control board to U21 on the channel board. The recorder is designed to drive up to 1 mA DC into a 1 K ohm impedance recording device, or alternatively a 0 volt to 10 volt DC signal to a high impedance. AR4 is a -10 volt reference for the D/A.

5. **Digital Circuits.** The Input Channel Module is controlled by an eight-bit microprocessor which performs the following functions:

a. A/D synchronization.
b. Zero determination.
c. Zero correction.
d. Ranging.
e. Channel calibration.
f. Processing of measurement data (digital filtering).
g. Transmission of measurement data to and from the control board.
h. Recorder output.
i. Instrument trigger synchronization.

The Input Channel uses a Z-80 microprocessor U2, with random-access-memory (RAM) U3, and read-only-memory (ROM) U1. Program instructions that control the activity of the board are stored in the ROM. The RAM is used to store both temporary and permanent data . Calibration constants for gain, range, digital filter

selection, measurement values, and zero correction data are stored in the RAM. BT1 is a lithium battery which provides backup power to the RAM making it a non-volatile memory. A bit switch, S1, is provided to configure the processor for alternate uses. Integrated circuit U4 is a data buffer between the microprocessor and switch and the chopper drive. The microprocessor monitors the chopper drive to maintain synchronization of the A/D with the chopper drive. The control board accesses the input channel RAM through the line buffers U7, U8 and U9 and the card edge connector. All communications between the control and channel boards is via memory locations in the channel RAM. When the channel RAM is accessed by the control board the channel Z-80 is halted for 100 microseconds or less.

5-4. CONTROL BOARD.

1. **General.** Refer to Figure 5-3. The operation of the instrument is under control of a microprocessor (μP). Associated hardware includes the (RAM), (ROM), I/O devices, and a number of logic gates used as system 'glue'. Control board functions are as follows:

a. Signal processing (shaping).
b. Calibration.
c. Power to dB conversion.
d. Recorder output processing.
e. Diagnostics.
f. Keyboard and display control.
g. GPIB control.

2. **Microprocessor Circuits.** The microprocessor (μP) U19, is a 68008 which operates at a clock frequency of 8 MHz. The software resides in ROM U6, U10 and U18. ROM U6 stores the control program. U18 stores the tables of functions pertinent to the many sensors available for use with the instrument. ROM U10 contains software and tables for implementation of MATE on the GPIB.

Lithium battery BT1, provides backup power to the RAM. A memory protection circuit, U17a, c, and d, eliminates the possiblity of erroneous data being written to the RAM during uncertain circuit conditions that occur at power-up or power-down.

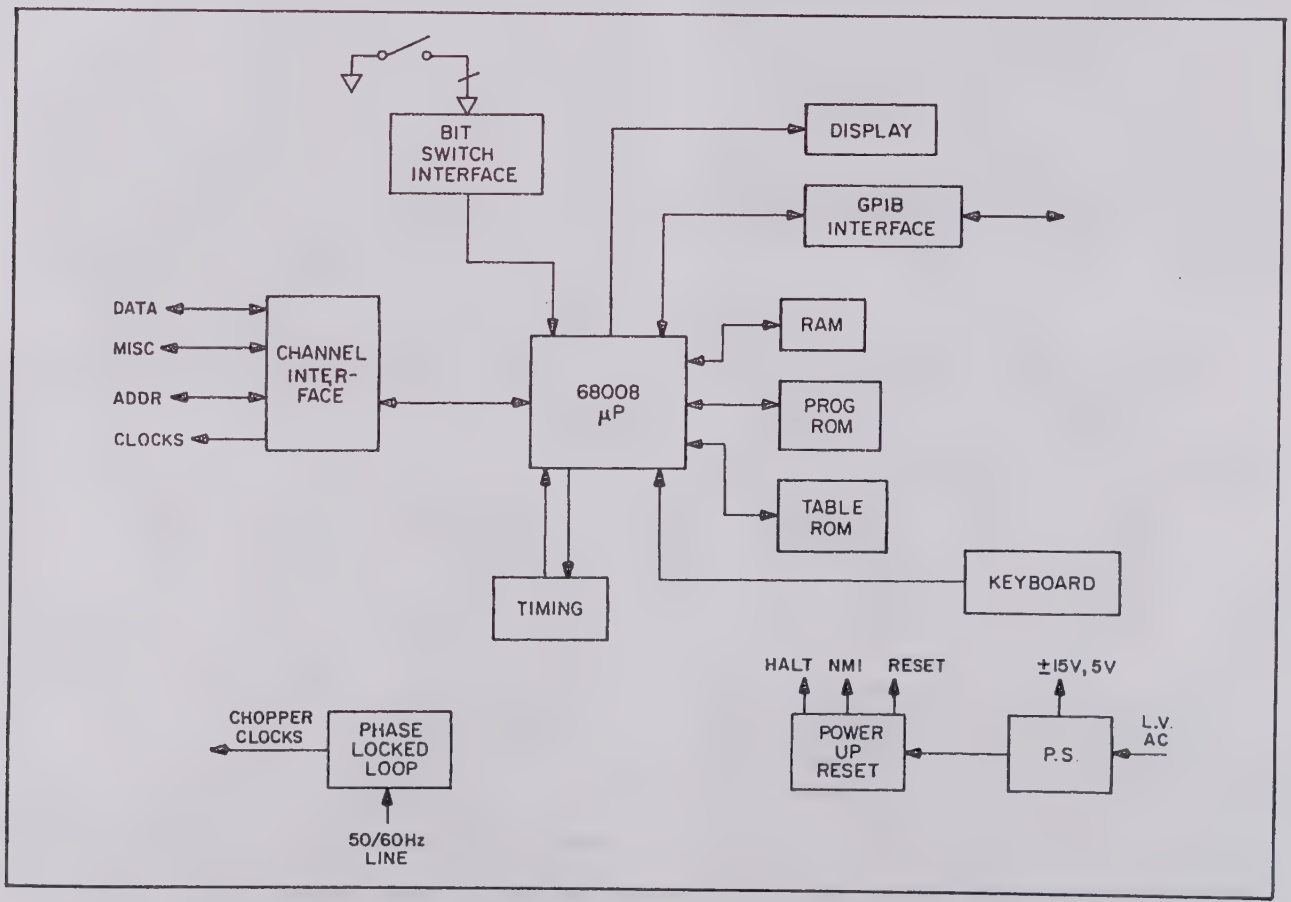

Figure 5-3. Control Board Block Diagram

Each circuit associated with the μP has a unique timing requirement. The RAMs and ROMs; for example, are much faster than I/O circuits such as the channel or calibrator assembly. The μP has the capability to change the speed of data exchange to match the parameters of both memory and I/O. The system clock frequency of 8 MHz is divided by U11, a divide by 16 counter to give both a 2 MHz and 4 MHz clock frequency. Gates U13a, b, c output logic signals which cause latch U8a, b to capture the period of either the 2 or 4 MHz clock. The period is sensed by the μP DTACK input and is used as timing for I/O and memory. Signals FC0, FC1 and FC2 from the μP are combined in U14a, b and U16e to initiate the auto vector interrupt mode of the μP. Integrated circuits U1, U2, U3 and U4 provide buffering between the μP and channels.

3. **Display Circuits.** The (LCD) liquid-crystal-display is controlled by integrated circuit U24 which buffers data flow between the μP and display. OR gate U15d ensures correct timing of the data transfer. Voltage regulator U29 provides -5V to adjustable potentiometer R27, which adjusts the LCD viewing angle and contrast.

4. **Keyboard Circuits.** The keyboard is controlled by IC U34 and provides the following functions; automatic scanning of the keyboard for key switch closure, First-In-First-Out RAM storage for up to 8 keystrokes of input commands, and keystroke debouncing. Keyboard data is passed to the μP on the data bus.

5. **GPIB Circuits.** The GPIB General-Purpose-Interface-Bus is controlled by IC U32 which is a microprocessor drive data interface which converts IEEE-488 bus compatible signals into control codes that operate the internal functions of the instrument. It also converts instrument data into IEEE-488 compatible signals for transmission on the bus. Integrated circuits U25 and U26 are buffers between the GPIB controller and the bus.

6. **Power ON Reset Circuits.** All of the microprocessors in the instrument require signals to properly initialize and end their operation when the instrument power line is switched. An IC comparator, U22a, b, c, is used to monitor the status of the line via voltages present in the power supply and generate NMI, HALT, and RESET in the correct sequence. Refer to the timing diagram on the schematic. Time delays in the sequence are determined by R12-C13 and R18-C14. IC U23a, b, c, and e are buffers. Operation is such that a momentary power outage will reset the instrument.

R9 is set so that when the unregulated 5 V (8-12 V) drops below 8 V, and NMI is generated (8 V is the minimum level that will guarantee 5 V at the output of the regulator U1). The NMI stops the 68008. The halt and reset lines then (go active) in sequence. Since U23 is an open collector, the rise time is much longer than the fall time, assuring on power up that the power supply has had time to move away from the 8 V threshold.

7. **Chopper/Line Synchronization Circuits.** The channel and the chopper assemblies receive drive signals which are synchronized to the power line frequency. Synchronization to the line aids in the rejection of line produced noise from the sensitive input circuitry and the input cables, because the noise is repeatable from cycle to cycle and can therefore be zeroed out. Synchronization is accomplished by sampling of the AC voltage at the secondary of the power transformer by U37, CR8 and CR9. A Phase Lock-Loop of U35 and U36 generate square wave signals at 480 Hz and 1920 Hz in phase with the line.

The instrument's power line frequency response is specified over a range from 50 Hz to 400 Hz. At line frequency other than 50/60 Hz another method of deriving chopper drive is needed. Binary divider U21 is the contingency method of generating the chopper drive signals. A 1 MHz signal is frequency divided to produce 488 Hz and 1953 Hz.

5-5. 30 MHz CALIBRATOR.

1. **General.** Refer to Figure 5-4. The calibrator is a microprocessor-controlled, software-calibrated 30 MHz crystal controlled generator. The described power output may be programmed via the keyboard or via the IEEE-488 bus in 1 dB steps from +20 dBm to -60 dBm. The output impedance is 50 Ω at 30 MHz.

2. **Oscillator Circuits.** Transistor Q1, crystal Y1, and the associated components form an oscillator. The oscillator is buffered by emitter follower Q4. During normal operation, the base of Q2 is held low by the 82C55, however, when the zero button is depressed on the front panel, transistor Q2 is cut off, cutting off Vcc supply to the oscillator and the buffer.

3. **Power Amplifier Circuits.** Transistor Q5 is configured for class C operation. The power output is a function of Vcc supply through Q2 which is controlled by the leveling loop. The power output is linear to .01 dB over a 10 dB range. This signal is applied to a low-pass filter by the tuned circuit C12 and L6.

4. **Low-Pass Filter Circuits.** The low-pass filter consists of L7, L8, C14, C17, C16 and C18. The harmonic content is reduced to -65 dB by this filter

5. **Amplitude Control and Leveling Loop Circuits.** During calibration, compensation data peculiar to a given attenuator in each calibrator is stored in the calibration EPROM U3. One constant is stored for each full scale output (10 dB step). The DC voltage from the DAC is filtered by C3, temperature compensated by RT1 and R18 and applied as set-point for the integrator AR1. The 30 MHz signal from the low-pass filter is detected by

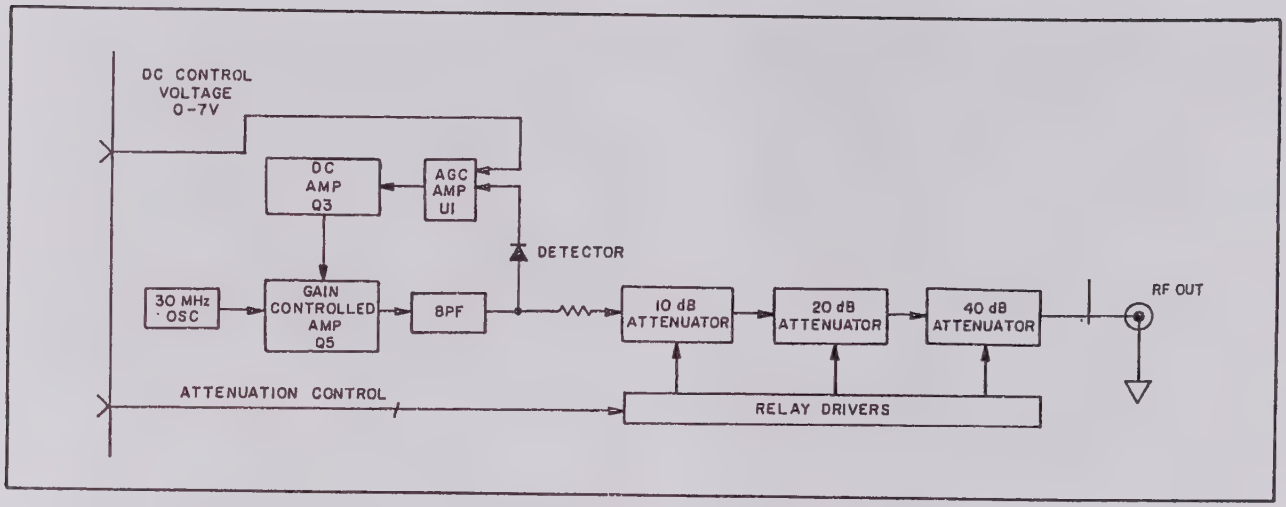

Figure 5-4. 30 MHz Generator Block Diagram

CR3 and filtered by C15, and applied to pin 2 of AR1. The detected level is compared to the DAC voltage in the integrator. The DAC provides the calibrated full scale voltages for each 10 dB increment, and also is used to step the output in 1 dB steps. Unequal loading resistors on the AC detector diode and the DC compensation diode compensate for the slight inefficiency of the AC detector (it tends to have an output component that is a result of the diode integrating over the 30 MHz cycle). The integrator controls the Vcc supply to the power amplifier and therefore the power output. Capacitor C10 provides the necessary loop compensation. This integral feedback loop connection makes the junction of R19, CR3 and C20 as a voltage source which tracks the reference voltage. Therefore, the (4) 200 Ω in parallel along with compensated switch contacts make the output impedance 50 Ω at 30 MHz.

6. **Attenuator Circuits.** The attenuator consists of a 10 dB, 20 dB and 40 dB pads respectively. The complete amplifier/attenuator chain is programmable in 10 dB and 1 dB steps for maximum attenuation of 80 dB. Q6-Q8 are relay drivers.

7. **30 MHz Digital Board A3.** Refer to Figure 5-5. The unipolar configuration of the D/A will provide 0 to +10 volts. This voltage is used as the reference voltage for the leveling loop. The typical DC voltage for full scale (+20 dBm, +10, 0, etc.) is 6.7 V and 2.38 V for downscale (-9 dB).

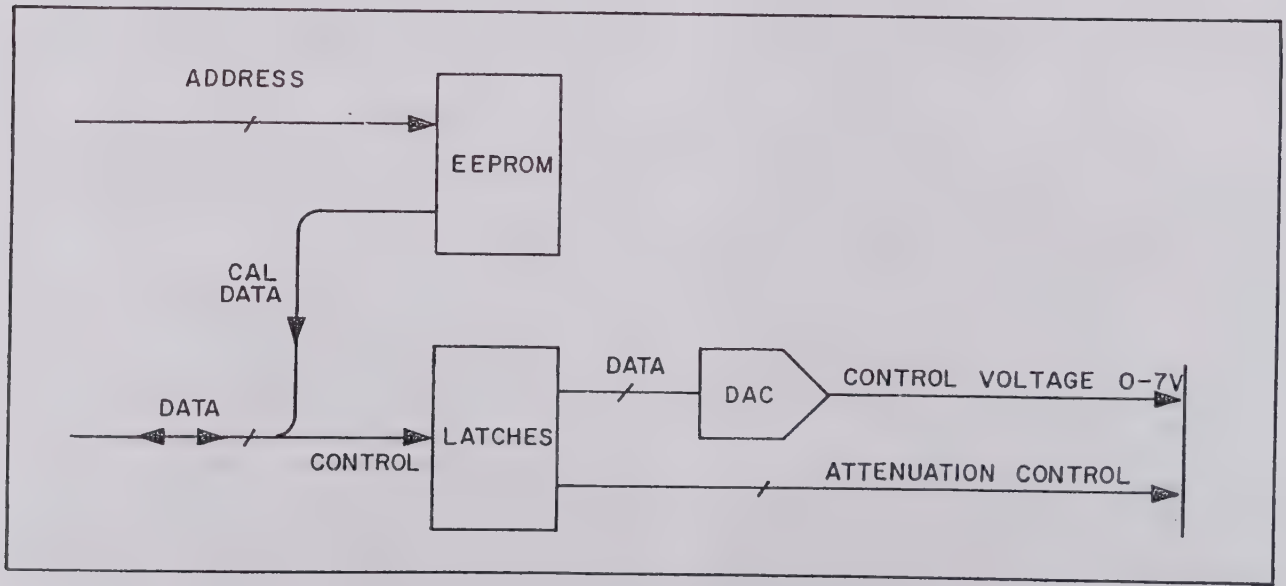

Figure 5-5. 30 MHz Digital Block Diagram

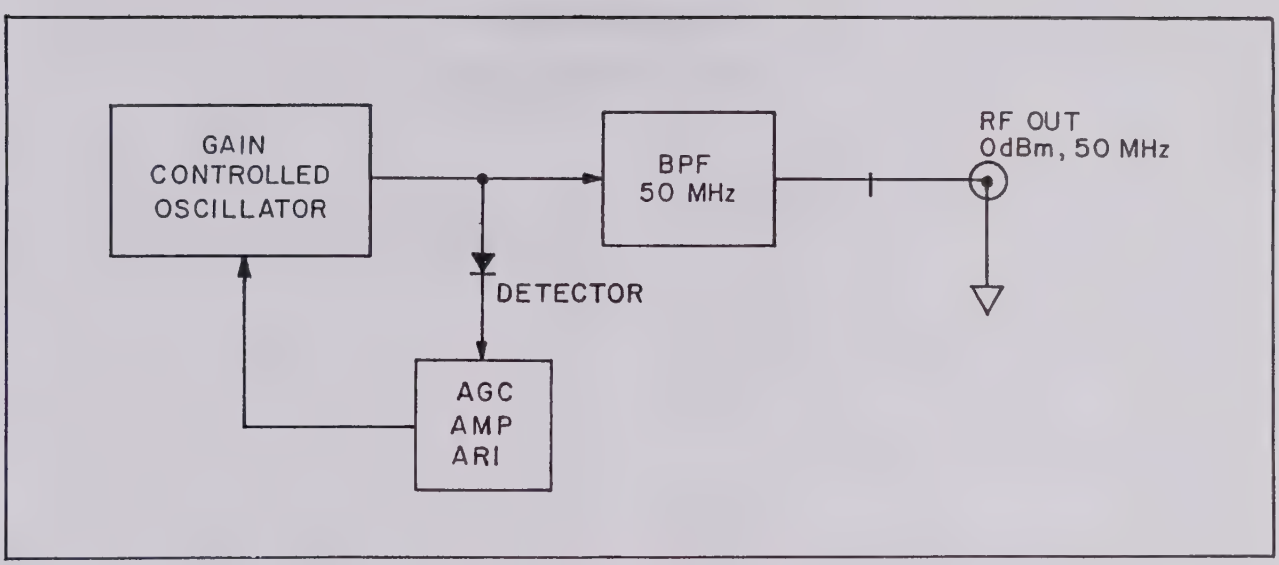

Figure 5-6. 50 MHz Calibrator Block Diagram

5-6. 50 MHz CALIBRATOR.

Refer to Figure 5-6. The reference signal is generated by transistor oscillator Q1, which operates at 50 ±0.5 MHz. An automatic leveling circuit is used to maintain a constant reference power level. Leveling is achieved by rectifying the oscillator output signal in the signal level detector circuit, and comparing the resulting DC voltage with a stable DC voltage developed by voltage reference IC1. The difference voltage is amplified by operational amplifier A1, and the output level from the operational amplifier controls a varactor in a capacitive divider that determines the drive to the oscillator. A second capacitive divider at the output of the oscillator divides the oscillator output signal and tends to provide some isolation from the load. The sense point for the leveling loop is at the junction of L1 and L2, so this is a zero impedance point for AC. Therefore, a 50 ohm series resistor is used to establish the desired 50 ohm source resistance. The output reference power level signal is available at the front panel POWER REF connector.

SECTION 6
MAINTENANCE

6-1. INTRODUCTION.

This section contains the safety requirements, test equipment required, cleaning procedures, removal and replacement procedures, inspection procedures, and three major subsections:

6-100. PERFORMANCE TESTS.
6-200. ADJUSTMENTS.
6-300. TROUBLESHOOTING.

6-2. SAFETY REQUIREMENTS.

Although this instrument has been designed in accordance with international safety standards, general safety precautions must be observed during all phases of operation, service and repair of the instrument. Failure to comply with the precautions listed in the Safety Summary at the front of this manual or with specific warnings given throughout this manual could result in serious injury or death. Service and adjustments should be performed only by qualified service personnel.

6-3. TEST EQUIPMENT REQUIRED.

Test equipment required for the performance tests, adjustments, and troubleshooting is listed in Table 6-101.

6-4. CLEANING PROCEDURE

Painted surfaces can be cleaned with a commercial, spray-type window cleaner or with a mild soap and water solution.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in the instrument. Recommended cleaning agents are isopropyl alchol, kelite (1 part kelite, 20 parts water), or a solution of 1% mild detergent and 99% water.

6-5. REMOVAL AND REPLACEMENT.

1. **Instrument Covers.** Remove the instrument covers as follows:

a. Disconnect the power cord and all signal cables from the instrument.

b. Remove the three screws located at the rear of the cover.

c. Slowly lift the cover up and to the rear.

d. Remove the shield on the left side of the instrument.

e. Turn the instrument over and remove the bottom cover in the same manner as the top cover was removed.

f. Remove the bottom shield.

g. To replace the covers reverse the removal procedure.

h. Refer to Section 2 for removal and installation of modules.

6-6. INSPECTION.

If an equipment malfunction occurs, perform a visual inspection of the Model 4300. Inspect for signs of damage caused by excessive shock, vibration, or overheating, such as broken wires, loose hardware and parts, loose electrical connections, electrical shorts, cold solder connections, or accumulations of dirt and other foreign matter. Correct any problems discovered, then perform the performance tests to verify that the instrument is operational. If a malfunction persists or the instrument fails any of the performance tests refer to the adjustment procedures. After the instrument has been adjusted, perform the performance tests again to verify instrument operation. If the instrument cannot be adjusted, or fails the performance tests refer to the troubleshooting procedure.

TABLE 6-101. MAINTENANCE TEST EQUIPMENT

Equipment	Specification	Suggested Model
Signal Source	Must cover range of levels compatible with the sensor to be used.	Boonton Model 2520 Boonton Model 25A HP 3335A
Milliwatt Test Set	±0.015 dBm at a level of 0.00 dBm.	Wandel and Goltermann Model EPM-1 with TK-10 probe
Counter	50 MHz	Ballantine Model 5500B
Oscilloscope	Bandwidth of 100 MHz. Sensitivity of 5 mV/div.	HP Model 1740A with a 10X probe
50 Ω Termination	50 ± 1 ohm	Boonton Model 91-15A
DC Voltmeter	.05% basic accuracy	Fluke 8840A
10 dB fixed Attenuator	50 ohm, N type conn. 10 dB ±0.5 dB.	Weinschel Engineering Model 1
20 dB fixed Attenuator	50 ohm, N type conn. 20 dB ±0.5 dB	Weinschel Engineering Model 1
30 dB fixed Attenuator	50 ohm, N type conn. 30 ±0.75 dB.	Weinschel Engineering Model 1
40 dB fixed Attenuator	50 ohm, N type conn. 40 ±0.75 dB.	Weinschel Engineering Model 1
Calculator	Scientific key for the antilog function.	Hewlett Packard #21
2 dB fixed Attenuator	50 ohm, N type conn.	Weinschel Engineering Model 1
4 dB fixed Attenuator	50 ohm, N type conn.	Weinschel Engineering Model 1
6dB fixed Attenuator	50 ohm, N type conn.	Weinschel Engineering Model 1
8 dB fixed Attenuator	50 ohm, N type conn.	Weinschel Engineering Model 1
DC Range Calibrator	Differential, adjustable source impedance	Boonton Model 2500 Boonton Model 2510
Coaxial Switch (optional)	N type connectors	HP 8761B
Sensors	N connectors	Boonton Model 51013 and 5105
Variac	± 30% of nominal line voltage.	

SECTION 6-100
PERFORMANCE TESTS

6-101. INTRODUCTION

The performance tests should be performed about every 12 months or after the instrument has been repaired. The performance tests may also be performed when the Model 4300 is first received to verify instrument performance.

The Performance Tests consist of the following:

1. Power Supply Test.
2. Battery Test.
3. Display Test.
4. Key Test.
5. Memory Test.
6. Bit Switch Test.
7. ROM Test.
8. Bus Test.
9. Chopper Offset Test.
10. Reference Frequency Accuracy Test.
11. DC Calibration Test.
12. Auto Calibration Test.
13. 30 MHz Calibrator Performance Tests.
14. 50 MHz Calibrator Performance Tests.
15. Chart Recorder Verification Test.

6-102. POWER SUPPLY TEST.

WARNING

There are voltages at various points in the instrument which can, if contacted, cause personal injury. Observe all safety precautions. Service and adjustment should be performed by trained service personnel only.

Perform the power supply test as follows:

1. Remove all power from the instrument.

2. Remove the top cover of the instrument and the EMI shield on the left side of the instrument.

3. Apply power to the instrument and set the LINE ON/OFF switch to ON.

4. Connect a DVM to A7TP9 and ground; the voltage should be +5 vdc ±5%.

5. Connect a DVM to A7TP10 and ground; the voltage should be +15 vdc ±5%.

6. Connect a DVM to A7TP12 and ground; the voltage should be -15 vdc ±5%.

6-103. BATTERY TEST. Perform the battery test as follows:

1. Press TEST, &, ENTER.

2. The display will indicate one of the following:

a. "Battery OK". There are no failures found by this test.

b. "Battery Fail". A display showing the letter 'C' indicates a failure on the control board. A number in a box indicates the channel on which the failure occurred. When multiple failures occur, the display indicates all failures simultaneously.

Example: C 1 3 4 6

indicates failure on the control board, channel 1, channel 3, channel 4 and channel 6.

3. Press ESCAPE to return the instrument to the measurement mode.

6-104. DISPLAY TEST. Perform the display test as follows:

1. Press TEST, 2, ENTER.

2. The display will indicate the following, in sequence:

a. "Display Test".

b. A display consisting of all characters lit forming 80 underscored rectangles.

c. A display of the entire alphabet set, and special characters.

3. Press ESCAPE to return the instrument to the measurement mode.

6-105. KEY TEST. Perform the key test as follows:

1. Press TEST, 1, ENTER.

2. The display will indicate "Key Test".

3. Observe the 4300 display and press each key listed in Table 6-102. As the key is pressed the code number corresponding to that key should be displayed.

TABLE 6-102. KEY TEST KEY CODES

[**]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[26]	[27]
[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[25]	[28]
[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]	[27]

** = [ESCAPE] key

4. Press ESCAPE to return the instrument to the measurement mode.

NOTE

The instrument will return to the measurement mode after some time period or after 40 keystrokes (any sequence of keys).

6-106. MEMORY TEST. Perform the memory test as follows:

1. Press TEST, 3, ENTER.

2. The display will indicate one of the following displays:

a. "Memory OK".

b. "Memory Fail". A display showing the letter 'C' indicates a failure on the control board. A number in a box indicates the channel on which the failure occurred. When multiple failures occur, the display indicates all failures simultaneously.

Example: C 1 3 4 6

indicates failure on the control board, channel 1, channel 3, channel 4 and channel 6.

3. Press ESCAPE to return the instrument to the measurement mode.

NOTE

The Memory Test will not detect certain memory failures. For example, random bit dropouts that occur over a period longer than that of the memory test.

6-107. BIT SWITCH TEST. Perform the bit switch test as follows:

1. Press TEST, 4, ENTER.

2. The display will indicate the following:

"C swl B B B B B B B B"

B's designate bits (the MSB is at the left)

3. Press any key except ESCAPE.

4. The display will sequence through the following patterns for each channel that is installed (empty channels will be skipped). Refer to the Notes below for the meaning of the displays.

a. " C sw2 B B B B "
b. " 1 swl B B B B "
c. " 2 sw2 B B B B "
d. " 3 sw3 B B B B "
e. " 4 sw4 B B B B "
f. " 5 sw5 B B B B "
g. " 6 sw6 B B B B "

NOTES

" C swl " specifies the control assembly switch 1.
" 1 swl " specifies " channel 1 switch 1 ".

5. Press ESCAPE to return the instrument to the measurement mode.

6-108. ROM TEST. Perform the ROM test as follows:

1. Press TEST, 6, ENTER.

2. The display will indicate the following:

"BOONTON ELECTRONICS CORPORATION TABLE ROM"
"4300 Version V.VV* Version V.VV"*

* V.VV = the resident software version

3. Press any key except ESCAPE.

4. The display will sequence through the following patterns for each channel/calibrator that is installed.

a. "MATE ROM Version V.VV"
b. "CALIBRATOR Version V.VV"
c. "CHANNEL 1 Version V.VV"
d. "CHANNEL 2 Version V.VV" etc. . . .

5. Press ESCAPE to return to the measurement mode.

6-109. BUS TEST.

1. Refer to Figure 6-101. The bus test is a debugging aid. When selected, this command will cause the instrument to enter a special submode where the display is used to show information about the IEEE-488 interface. The information on the display can be broken up into four different groups. They are the Bus test message in the upper right, Bus operating status lower right, Bus line status lower left, and the present listen buffer image of the instrument in the upper left.

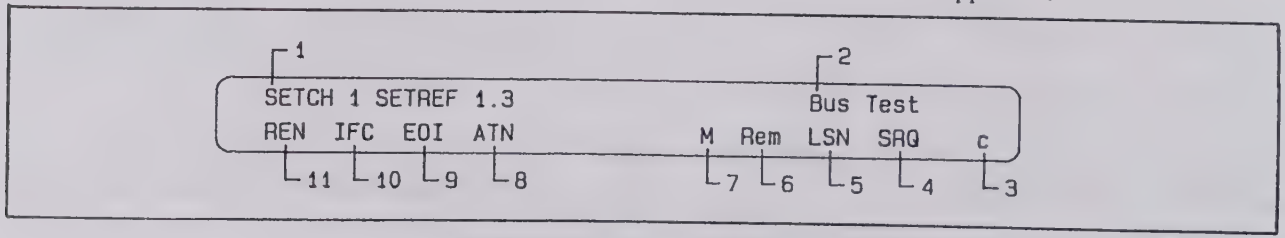

Figure 6-101. Bus Test Display

2. The Bus test message (item 2) indicates that the bus test submode is active.

3. The bus operating status (items 3 through 7) indicates the current operating status of the instrument on the bus. This display is active whenever the instrument is active on the bus. The "M" character (item 7) only appears if the instrument has the MATE option installed and the unit is operating in the MATE mode on the bus. The "Rem" (item 6) message appears when the instrument goes remote in response to a controller request. The "LSN" message (item 6) shares its location with the "TLK" message. These messages indicate if the instrument is addressed to listen or talk by the controller. This location can be shared because an instrument can not be addressed to talk and listen at the same time. The "SRQ" message (item 4) indicates that the instrument is requesting service from the controller but the controller has not yet responded. The "c" character (item 3) can appear when the instrument is in any mode of operation and indicates if the internal programmable calibrator output is enabled.

4. The bus line status section of the display shows the condition of the specific hardware lines on the bus. If the message appears then the signal is active on that line. The "REN" message (item 11), which stands for Remote Enable, indicates that a controller is active on the bus and is required for the instrument to be able to go remote. This message should always be present during operation, if not, check the cable connections and then check that the controller is active and is asserting this line. The "IFC" message (item 10), which stands for Interface Clear, is a command signal for all instruments on the bus to clear their interfaces. This line should only be active for short periods of time, if not, all the instruments on the bus will appear inoperatable. The "EOI" message (item 9), which stands for End or Identify, is a command signal asserted by the current talker and can be used by all listeners to mark the last character in the transmission of a message. The use of this line is optional but the 4300 uses it for talking and listening, in addition to the inline termination characters. If not functioning properly this line can cause the instruments on the bus to hand the bus waiting for proper message termination. The "ATN" message (item 8), which stands for Attention, is a signal that can only be asserted by the controller in charge. This signal is used by the controller to take control of the bus, which means all instruments must stop bus operation and obey the controller. This line is very important to correct operation of the bus and will normally be asserted at periodic intervals by the controller to perform normal operations on the bus.

5. The instrument image buffer (item 1) is an area on the display which shows up to 29 characters of the 4300 instrument listen buffer. This window allows the user to view the messages sent to the instrument. The listen buffer is 512 bytes long in the instrument, so the + and – keys on the front panel can be used to scroll the entire buffer through the window. The (CLR) key will move the window back to the beginning of the buffer, so that the left most character in the display is the first character in the buffer. The solid block that appears on the display marks the end of the current message in the buffer.

6. There are primarily three ways to make use of the bus test function. One is to check the status of the signal lines. The second is to break up the bus operation of the instrument into steps. This can be done by activating the bus mode of the instrument before performing any operation. This prevents the instrument from acting upon any messages sent to it. The message will be read into the listen buffer and the display window will be updated but no action will be taken to parse the string and execute the command until the bus test mode is disabled by pressing the escape key. This breaks the instrument operation up into steps, which allows the operator to verify the reception of the message string before its execution but does not change how the instrument will act upon the command string. The third method is to use the bus test when the instrument responds with the illegal bus command error message. To find out what command in the bus string was not understood by the instrument press the ESCAPE key to clear the error condition and then select the bus test (test 5). What will happen at this point is that the listen buffer display will come up with the word it did not understand starting in the left most part of the window. Then if more examination of the data is required, the "+" key, the "–" key and the "(CLR)" key could be used to move through the buffer to view other areas.

6-110. CHOPPER OFFSET TEST. Perform the test as follows for each input board installed:

1. Connect an oscilloscope probe to input board TP13 (accessible from the top) and set the oscilloscope for 2 V per division and 2 mS per division, internal trigger.

2. Connect the Model 2500 or 2510 DC Range Calibrator to the sensor input connector, front or rear, and press ZERO. Alternatively, connect a sensor to the input with no applied RF power.

3. Observe the oscilloscope and verify that a square wave <3 V peak to peak, with considerable noise on it, is present.

6-111. REFERENCE FREQUENCY ACCURACY TEST.

1. Connect the sensor(s) to the channel(s) to be tested.

2. For each sensor, enter the sensor type and serial number if not entered already, and assign the sensor to the appropriate channel in single channel mode. See the

Operations Section, SENSOR DATA ENTRY key for information on this.

3. Press SHIFT, RECALL, 0, ENTER. This puts the 4300 into single channel mode on channel 1.

4. Select the channel to be checked by pressing SHIFT, SET CH, n, ENTER, where n is the channel number from 1 to 6.

5. Connect the sensor to either the 30 or 50 MHz internal calibrator. If no calibrator is installed, or if the sensors are waveguide sensors, connect it to an external calibrator at 0 or -20 dBm. Press SHIFT, AUTOCAL. Press ENTER if and when prompted by the display and wait for the autocalibration cycle to complete (about 100 seconds if the 30 MHz calibrator is installed).

6. Connect the sensor to an external calibrator which is to be set to the reference frequency shown in Table 6-206, Reference Frequency. See the paragraphs in that section regarding coaxial sensor reference frequency.

7. Vary the output of the generator and take readings in dBm at the power levels shown in Table 6-103 or 6-104, Reference Frequency Accuracy. Verify that the readings agree to the set level within the required accuracy, where the required accuracy is:

Accuracy = Table Entry + Source Error + Shaping Error.

For the Boonton 25A the source error is .05 dB; for the Boonton 2520, it is level dependent; see the applicable spec sheet. For other manufacturers sources, see the applicable spec sheet.

The shaping error is .003 dB if the programmable 30 MHz calibrator is installed, and .04 dB if not (millimeter wave sensors have a shaping error of .04 dB).

6-112. DC CALIBRATION TEST. Perform the test as follows for each channel installed:

1. Let the 4300 warm up for at least 20 minutes and connect the Boonton 2500 or 2510 DC Calibrator to the first channel to be tested.

2. Set the 2500 to range 0 and 500 k ohms.

3. On the 4300 press SHIFT, RECALL, 0, ENTER, and SPCL, 8, ENTER. This places the 4300 in single channel mode, reading raw value.

4. Press SET CH, N, ENTER, where N is the number (1-6) of the channel to be tested.

5. Press FILTER, 5000, ENTER.

6. On the 2500 press the zero button to deactivate the signal. (On the 2510 press ON/OFF to deactivate the signal, as shown on its display.) Wait 10 seconds. On the 4300 press ZERO to initiate the zeroing cycle.

TABLE 6-103. REFERENCE FREQUENCY ACCURACY, COAXIAL SENSORS

	Sensor Type					
dBm	51011 51012 51013	51051	51015	51033	51016 *1	51017 *1
-60	0.75	0.40	---	—	—	—
-55	0.40	0.20	—	—	—	—
-50	0.20	0.11	0.75	—	—	—
-45	0.09	0.09	0 40	—	—	—
-40	0.09	0.09	0.20	0 75	—	—
-35	0 06	0.06	0.09	0.40	—	—
-30	0.06	0.06	0 07	0.20	—	—
-25	0.06	0 06	0 06	0.09	—	—
-20	0.06	0 06	0.06	0 06	0.75	—
-15	0.06	0.06	0 06	0.06	0.40	—
-10	0.06	0.06	0.06	0.06	0.20	0.75
-5	0.06	0.06	0.06	0.06	0.10	0 40
0	0.04	0.04	0 04	0.04	0.06	0.20
5	0.06	0.06	0.06	0.06	0.06	0.10
10	0.06	0 06	0.06	0 06	0.06	0 06
15	0.06	0 06	0.06	0.06	—	0.06
20	0.06	—	0 06	0 06	—	0 06
25	—	—	0.08	0.08	—	—
30	—	—	0.09	0.09	—	—
33	—	—	—	0.10	—	—

*1 The accuracy numbers are for the 4312 (Thermal) Input Modules, when using thermal sensors with 4311 (Universal) Input Modules, triple all table entries that are above (and including) 0.20 dB.

TABLE 6-104. REFERENCE FREQUENCY ACCURACY, WAVEGUIDE SENSORS

	Sensor Type		
dBm	51035 51036 51972	51037 51045	51046 51047
-50	0.75	0.80	0.90
45	0.62	0.75	0.82
-40	0.50	0.70	0.71
-35	0.42	0.62	0.66
-30	0.36	0.56	0.61
-25	0.31	0.51	0.56
-20	0.26	0.46	0.51
-15	0.31	0.51	0.56
-10	0.36	0.56	0.61
-5	0.41	0.61	0.66
0	0.46	0.66	0.71
5	0.51	0.71	0.76
10	0.56	0.76	0.81

7. On the 2500 release the zero button, activating the signal.

8. Observe the 4300 display and verify that 6635 ±100 counts is displayed.

9. Refer to the table and set the 2500 to ranges 1 through 6B and verify that the count tolerance is as specified in Table 6-105.

TABLE 6-105. DC COUNT TOLERANCE

Range	Count Tolerance
0	±100
1	±35
2	±25
3	±20
4	±20
5	±20
6B	±20

10. Repeat steps a through i for each channel installed.

6-113. AUTO CALIBRATION TEST (AUTO CAL).

NOTE

This test applies to coaxial sensors when the 30 MHz Calibrator is installed.

Perform the test as follows:

1. Connect the sensor to the channel assigned and connect the RF end to the 30 MHz Calibrator.

2. For each sensor, enter the sensor type and serial number if not entered already, and assign the sensor to the appropriate channel in single channel mode. See the Operations Section, SENSOR DATA ENTRY key for information on this.

3. Press SHIFT, AUTO CAL and then press ENTER as prompted. Wait for the auto calibration routine to finish (about 100 seconds). No error message should be displayed. If the display returns to normal with the right hand portion blank, the auto cal has been completed successfully.

4. Repeat steps 1 through 3 for all channels installed.

6-114. 30 MHz CALIBRATOR PERFORMANCE TESTS. This verification method uses a Wandel Goltermannn EPM-1 milliwatt test set to set the 0 dBm level, and fixed attenuators such as Weinschel Model 1's. The EPM-1 is traceable to the German National Physics Lab, with a basic accuracy at 0 dBm of +/- .015 dB, or to NBS. Alternatively, an HP432A power meter may be used along with a DVM; the HP478A-H55 and HP478-H75 power ahead calibrations are traceable to NBS. In this case refer to the HP432 instructions for "Precision Power Measurements", and replace the EPM-1 in the procedures below with the HP432.

ATTENUATOR CALIBRATION: If the exact attenuation of the pads is not known, they can be measured at DC. The DC attenuation is extremely close to the attenuation at 30 MHz, since the type N attenuators are being used at about 0.2% of their maximum frequency. Alternatively, the pads may be sent to NBS for certification at 30 MHz. To make the measurement, connect a stable DC source through two series 50 ohm resistors to ground. Type N connectors and soldered joints are essential to keep the ground offsets low. Adjust the center point voltage of the resistors for about 2 V, and record as V1. Now connect the pad under test between the two resistors, and measure the voltage at the output of the pad (V2). Calculate ATTEN = 20 log (V2/V1). The tolerance of the 50 ohm resistors does not affect the accuracy of this measurement on a first order approximation since the initial voltage was measured taking their actual values into account. The linearity of the voltmeter is important for this measurement.

PROCEDURE:

1. Power up the 4300 and let it warm up for 30 minutes.

2. Press RECALL, 0, ENTER. This puts the 4300 in a standard configuration (servs as an initialization) and sets it to channel 1. Any of the six channels can be used for this procedure, by selecting it from the front panel.

3. Connect a diode sensor (type 51013) to the channel 1 sensor input. Enter the sensor number (1-20) and type, and assign it to channel 1 (or the channel that is to be used). See the Operations Section for the sensor entry procedure. If a sensor is already entered into the instrument and assigned to a channel, this need not be done.

4. Press ZERO and wait for the zero cycle to complete. (The unit should be zeroed every few minutes or so, when making low level measurements.)

5. Press SHIFT, CALIBRATOR LIMIT, 20, ENTER.

6. Connect the equipment as shown in Figure 6-204. On the EPM-1, set the range switch to 0 dBm, and the resistance switch to 50 ohms. Adjust the calibration control on the EPM-1 for a null (0 dBm) indication. The EPM-1 should be nulled for a 0 dBm indication every 5 or 10 minutes.

NOTE

In the procedure below, be extremely careful to set the 4300 calibrator first, then connect it, because the EPM-1 is very sensitive to overloads.

7. 0 dBm VERIFICATION: Set the 4300 calibrator to 0 dBm by pressing LEVEL, 0, ENTER. Then connect the equipment as shown in Figure 6-205 and take a reading on the EPM-1. It should be 0 dBm to within the tolerance shown in Table 6-106.

TABLE 6-106. 30 MHz TOLERANCES

Level	Tolerance
0 dBm	.05 dB
+20	.07
+10	.07
+8	.07
+6	.07
+4	.07
+2	.07
-10	.02
-20	.02
-30	.03
-40	.04
-50	.07

This completes the verification of the 30 MHz calibrator.

8. +20 dBm VERIFICATION: Set the 4300 calibrator to +20 dBm with the LEVEL key and connect the equipment as shown in Figure 6-206 using the 20 dB attenuator. Take a reading on the EPM-1. The range switch on the EPM-1 may have to be used to get an onscale reading. (The range switch setting gets added to the overall EPM-1 reading.) The reading on the EPM-1 should be 20 - ATTEN where ATTEN is the exact attenuation of the attenuator, to within the tolerance in Table 6-106.

9. +1 to +10 dBm VERIFICATION: Using the same method as for the +20 dBm range, take readings at various power levels as shown in the table, and verify their tolerances. Use attenuators as required to bring the level down to 0 dBm.

10. -10 dBm THROUGH -50 dBm VERIFICATION: Connect the calibrator to the sensor as shown in Figure 6-208, with no attenuator. Turn off the calibrator and let the sensor settle for 40 seconds. Press SHIFT, AUTOCAL and ENTER as prompted by the display. Wait for the autocal cycle to complete (about 2 minutes).

11. Now set the calibrator to 0 dBm and insert the 50 dB attenuator in series with the sensor. Take a reading and call it R. Calculate:

R + ATTEN.

The result, neglecting the sign, should be less than the tolerance in the table. For example, if R is -50.27 and ATTEN is 50.25, the sum is -.02, which is the tolerance listed in the table.

12. Take similar "R" readings using the 40, 30, 20, and 10 dB attenuators, calculate their tolerances, and verify that they are within those listed in the table.

The tolerances in the table are derived from the requirements on 4300 internal attenuator accuracies, not absolute accuracies; therefore, taking measurements using the nonexact 0 dBm source is valid.

6-115. 50 MHz CALIBRATOR PERFORMANCE TESTS. The 50 MHz 0 dBm calibrator is checked using a Wandel Goltermann EPM-1 Milliwatt Test Set. Alternatively, an HP432 Analog Power Meter can be used in conjunction with a digital voltmeter and an NBS traceable power head (HP478A-H55 or HP478A-H75). In this case, refer to the HP432 manual for "precision power measurements", and replace the EPM-1 in the procedures below with the HP432.

The procedure is as follows:

1. Warm up the equipment for 30 minutes. Connect the EPM-1 power head to the EPM-1 input port as shown in Figure 6-204. Connect the thermistor power head RF port to the 0 dBm output on the EPM-1. Follow the manufacturers instructions for setting up the instrument as necessary. Adjust the front panel potentiometer for a 0 dBm indication on the analog meter.

2. Disconnect the RF port of the power head from the EPM-1 and connect it to the 4300 50 MHz output. Observe the analog meter. The indication should be 0 +/- .05 dB.

3. Measure the output frequence of the 50 MHz calibrator; it should be 50 +/- 0.5 mHz.

6-116. CHART RECORDER VERIFICATION TEST. Perform the test as follows:

NOTE

The chart recorder outputs are best checked with internal diagnostics that present a ramp to the output. The scaling is a software function and is checked indirectly with previous keyboard tests.

1. Set the Line ON/OFF power switch to OFF.

2. With the 4300 top cover removed, set the Input Channel Bit switches to activate the chart recorder ramp. See Table 6-202.

3. Set the line ON/OFF power switch to ON.

4. Set the oscilloscope horizontal scale to 100 μS/Div and connect the probe to the channel RECORDER OUTPUT connector to be tested. Verify that the waveform present is a double ramp, full scale 0-10 V ramp, followed by a smaller 0-0.156 V ramp. No discontinuities or erratic steps should be evident.

5. Reset the Input Module bit switches to the appropriate position.

SECTION 6-200
ADJUSTMENTS

6-201. INTRODUCTION.

The adjustments consist of the following:

1. Power-Up Reset Circuit Adjustment.
2. Initializing Via The Bit Switches.
3. 4300 Input Channel Adjustments.
4. 30 MHz Calibrator Adjustments.
5. 50 MHz Calibrator Adjustments.
6. DC Cal Factor Entry/Edit.
7. Sensor Data Entry.
8. Autocalibration.
9. AC Reference Frequency Calibration.

6-202. POWER UP RESET ADJUSTMENT, 4300.

1. Connect a variac between the 120 volt line and the 4300. Set the 4300 rear panel power switch for 120 V, and turn on the 4300.

NOTE

For adjustment using a 220/240 V line, set the rear panel switch to the 240 V position.

2. Monitor the AC line voltage going into the 4300 on a voltmeter and also monitor the regulated 5 volts on the control board on a scope. Sync the scope to the line.

3. Adjust the variac so that the regulated 5 VDC is just to the point of "dropping out".

4. Increase the AC voltage by 5 volts as indicated on the meter (10 volts for 240 V operation).

5. Monitor TP5 on the control board and adjust the power up reset pot so that TP5 is just dropping out, that is, a logic 1 with short pulses of logic 0.

6. Set the line voltage to 105 volts (210 volts for 240 V operation) and verify that the unit is still operating.

7. Power down the 4300 and disconnect the Variac.

6-203. INITIALIZING VIA THE BIT SWITCHES. Before adjustments are made to the 4300, initializing procedures should be done as shown below. Refer to Tables 6-201 and 6-202, and Figure 6-201 for the procedures on how to initialize and for descriptions of what is erased/modified with each procedure. Note that if the 4300 is inoperative, a hard reset, which erases most of the memory contents, may fix the problem. If a given channel has a problem, resetting that channel may fix the problem, although the DC calibration data that is printed on the label on the shield will have to be re-entered using SPECIAL 3 (this data is also in the envelope under the 4300 cover).

TABLE 6-201. INITIALIZATION

Condition	Initialization Procedure
1. Control board has been repaired and/or some sensor data has been corrupted.	Hard reset
2. Input channel(s) have been repaired, or need routine calibration.	Input channel reset
3. 30 MHz calibrator has been repaired or needs routine calibration.	Soft reset
4. 4300 malfunction	Hard reset
5. Power supply has been repaired.	Soft reset

6-204. INPUT CHANNEL ADJUSTMENTS. The input boards are calibrated to a DC source, from 9 microvolts to 4.5 VDC, differential, with an impedance 500 K ohms (universal boards, P/N 04311001*) or 1.8 K ohms, approximately, for thermal boards (P/N 0431103*). The Boonton 2500 or 2510 DC Calibrators provide these voltages with a Boonton type sensor connector.

1. Set the bit switches as shown:

Control Board	Input Board	Rear Panel
4 Off 3 Off 2 On 1 Off	All Open	All Closed

2. Power up the 4300 and wait 3 seconds. With the input board switches set as described, all the DC Gain constants will be set to nominal vlues, and any erroneous data will be erased. This also sets the input channel to range 0 (most sensitive range). (Strictly speaking the input channel would not have to be reset if it were known that the previous calibration data was within certain limits, but the reset operation starts the calibration procedure from a known baseline.) The control board position 2 switch enables (unprotects) the calibration.

3. **Chopper Offset Check:** Connect the Boonton 2500 DC calibrator to the sensor input and set the impedance to 500 K for universal channels (04311001*) or "low" for thermal channels (04311003*). Press the zero button on the 2500, disabling the source. Monitor

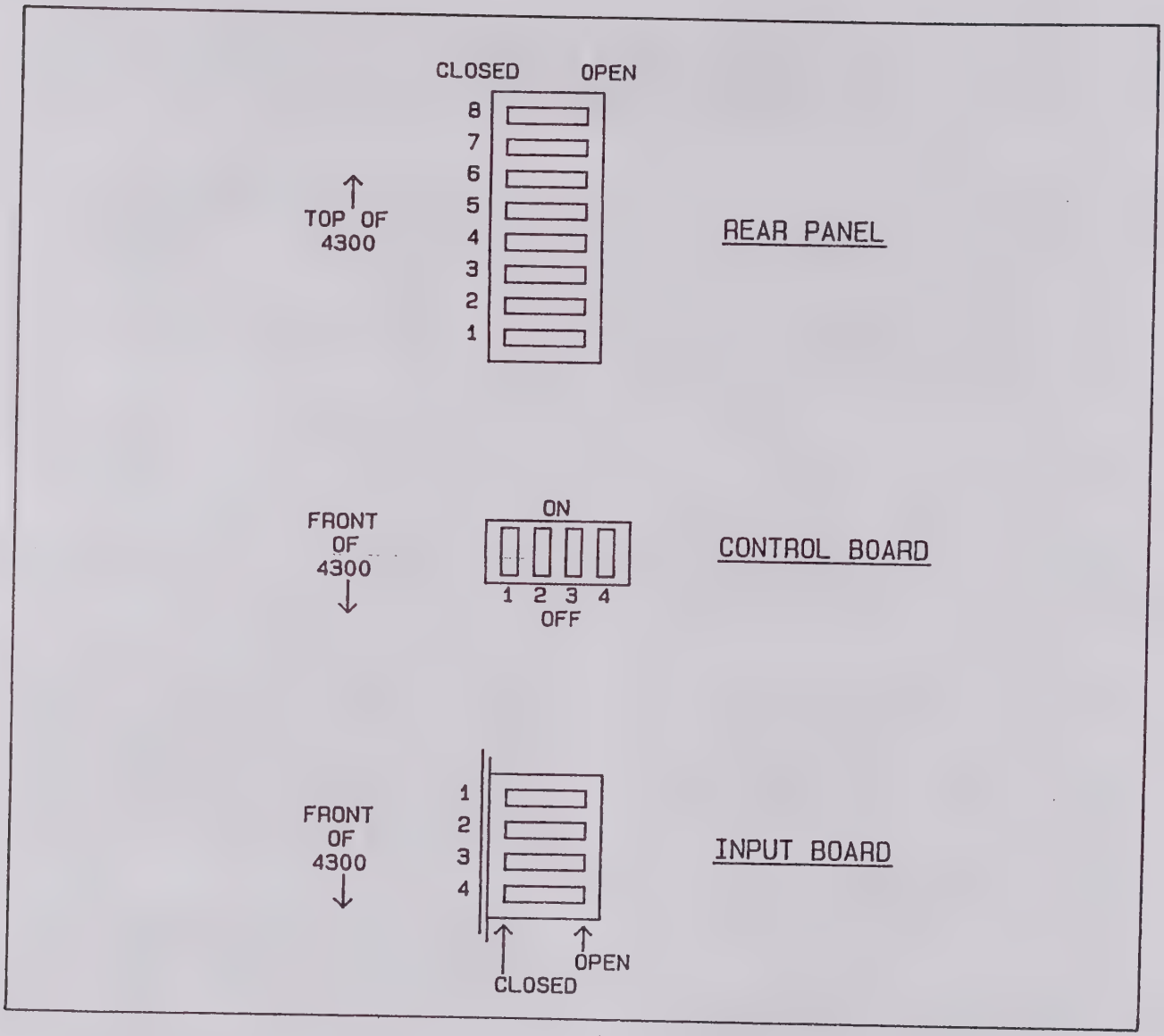

Figure 6-201. 4300 Bit Switch Diagram

TP13 on the Input Channel on the scope (2 mS per division and 1 V per division). There will be a noisy square wave at 240 Hz (sync the scope on TP14 or pin 4 of the chopper assembly if desired or, sync to the line). The amplitude should be less than 2 V p-p. If it is not, it will be necessary to remove the input board and adjust the chopper, as shown below.

4. **Chopper Adjustment:** Power down the 4300 and remove the input channel. Two screws on the bottom attach the shield to the bus board and one screw attaches at the rear panel. Also disconnect the two pigtail leads that connect to the front sensor connector (red goes to red and black goes to white). Put the board on the extender card and reconnect the 2500. Power up and monitor TP2 on the scope (2 mS per division and 1 V per division). TP2 is accesible through the 1" hole in the shield. Center the two pots (mechanically) on the chopper (two holes near the bracket assembly), and also the "tilt" pot R46 on the input board. Then adjust the two chopper pots in equal opposite directions until a minimum signal appears at TP2. Adjust the tilt pot for flat slopes. Then touch up the chopper pots once more, this time monitoring TP13 on the input board (this is the filtered signal).

Put the board back in the unit and check the chopper voltage again using the 2500.

TABLE 6-202. BIT SWITCH FUNCTIONS

REAR PANEL:

Position	Closed	Open
1	LF terminates Listen mode.	CR terminates Listen mode.
2	LF terminates Talk mode	LF does not terminate Talk mode (can be used with Pos 3).
3	CR terminates Talk mode. Note: To send no terminators, open positions 2 and 3.	CR does not terminate Talk mode (can be used with Pos 2).
4	MATE Disabled.	MATE Enabled.
5	Not used.	
6	Unprotect sensor entry; data may be entered from the front panel. The Control board switch position 2 must be set to 1 also to unprotect. If desired, the control board switch may be left set to 1, so that the covers need not be removed to change sensor data. The unit is shipped with both switches set for protection.	Protect sensor data entry or modification from the front panel.
7	Range the display (decimal point) along with the input board hardware range (amplifier range). This is the standard mode.	Range the display (decimal point) with the displayed value. The readout in watts or dBm is fixed to 4 digits.
8	Normal power up; parameters are retained.	Soft reset on power up; sets to channel 1, dB CF set to 0, etc. Equivalent to pressing "RECALL, 0, ENTER" (basic initialization). Note: If the control board switch position 1 is "on" at the same time, a hard reset will occur (master reset, erasing all sensor data, etc.).

CONTROL BOARD:

Position	Off	On
1	Hard reset disabled.	Hard reset on power up; this is a master reset which erases all sensor data and operating parameters. The input board DC gain constants are not affected. The rear panel switch position 8 must be set to open for a hard reset to occur. A hard reset is generally done when repairs on the control board have corrupted the memory contents.
2	Protect input board DC gain constant modification from the front panel, and protect recalibation of the 30 MHz Calibrator from the front panel. The 30 MHz Calibrator also has a jumper on it which must be in place to recalibrate. The jumper is removed at the factory.	Unprotect input channel DC gain constant modification and 30 MHz calibrator recalibration from the front panel. See note at left regarding jumper.
3	Protect sensor data entry from the front panel.	Unprotect sensor data entry from the front panel. May be left in the unprotect mode if desired. Position 6 on the rear panel must also be set to closed to unprotect.
4	Not used.	

TABLE 6-202. BIT SWITCH FUNCTIONS (Cont.)

INPUT CHANNEL(S) Position				(C = Closed, O = Open) Function
1	2	3	4	
C	C	C	C	Normal operating position for universal channels; Sets default filter to 2.8 seconds on range 0.
C	C	C	O	Normal operating position for thermal channels; Sets default filter to 4.8 seconds on range 0.
C	C	O	C	Diagnostics: RAM test. See Troubleshooting.
C	C	O	O	Diagnostics: Chart recorder test. See Troubleshooting.
C	O	C	C	Diagnostics: Decoder test. See Troubleshooting.
C	O	C	O	Diagnostics: 1ADTEST. See Troubleshooting.
C	O	O	C	Diagnostics: 2ADTEST. See Troubleshooting.
C	O	O	O	Adjustments: See Input Board Adjustments.
O	C	C	C	Adjustments: See Input Board Adjustments.
O	C	C	O	Adjustments: See Input Board Adjustments.
O	C	O	C	Puts settled reading on chart recorder output as a level; Default filter set to 2.8 seconds on range 0 (universal channels).
O	C	O	O	Puts settled reading on chart recorder output as a level; Default filter set to 4.8 seconds on range 0 (thermal channels).
O	O	C	C	Not used.
O	O	C	O	Not used.
O	O	O	C	Not used.
O	O	O	O	Resets Input Board. See Input Board Adjustments.

5. **DC Gain Adjustments.** Set the bit switch on the input channel to **all closed**. Power down and power up again **twice**, waiting 3 seconds each time the unit is powered up. This puts the input board in regular measurement mode.

6. Press: SHIFT, RECALL, 0, ENTER. This will put the 4300 in a standard configuration on channel 1.

7. Set the 4300 to the channel number that is being calibrated by pressing SHIFT, SET CH, N, ENTER, where N is the channel number (1-6).

8. Press the zero button on the Boonton 2500 DC Calibrator. Wait 5 seconds for the input board to stabilize.

9. Press ZERO on the 4300 and wait for the unit to complete its zero cycle, as indicated on the display.

10. Set the bit switch on the input board to:

1 Open
2 Closed
3 Closed
4 Closed.

11. Press: SPECIAL, 4, ENTER. This will put the 4300 in DC Cal mode.

12. Set the 2500 to range 5 and release the zero button on it, enabling the signal. On the 4300, press ENTER. The 4300 will take a measurement on range 5 and store this value. This value is used to generate "ADZERO", which is a downscale adjustment of the A/D converter. Wait 6 seconds or so for the cycle to complete.

13. Set the 2500 to range 4, and set the bit switch on the input board to:

1 Closed
2 Open
3 Open
4 Open.

14. Press ENTER. The 4300 will take a measurement on range 4, and generate "ADZERO", which can be extracted or modified with special function 3, at a later time. An allowable range for ADZERO is +/- 13.

15. Set the bit switch on the input board to:

1 Open
2 Closed
3 Closed
4 Open.

This is the basic setting for calculating the DC gain constants.

16. Press the zero button on the 2500, disabling the signal. Wait 10 seconds for the 4300 to stabilize, and press ZERO. Wait for the completion of the zeroing cycle.

17. Set the 2500 to range 1 and release the zero button, enabling the signal. Wait 2 seconds for the 4300 to stabilize, then press ENTER. Note: After the 4300 is zeroed, it will begin to drift. The time between zeroing and calibration of range 1 should be as short as possible.

The 4300 will calibrate on range 1, and after a few seconds, should indicate the result. The raw value as shown on the display should be 6635 +/- 15 counts, as shown in Table 6-203 below. Range 0 is not calibrated, since the noise on that range is greater than the non-linearity.

TABLE 6-203.
DC CALIBRATION TOLERANCE

Range	Tolerance
0	+/- 150 Counts
1	20
2	4
3	2
4	2
5	2
6B	2

18. Set the 2500 to range 2, and press ENTER. The 4300 should calibrate on range 2 and conform to the tolerance in Table 6-203.

19. Do calibration on ranges 3 through 6B in the same manner. Do not do ranges 0 or 6A.

20. Press: ESCAPE, SPECIAL, 8, ENTER, FILTER, 2000, ENTER. This takes the 4300 out of DC Cal mode and back into standard measurement mode, showing the units in raw value, with the filter at 2 seconds.

21. Press the zero button on the 2500 to disable the signal and press ZERO on the 4300.

22. Release the zero button on the 2500 and cycle the 2500 through the ranges and note the 4300 display. The raw value should be as indicated in Table 6-203, along with the tolerances. Occasionally, the board may latch onto a range that is one too high, because of range overlap. In this case disable the source momentarily to let the 4300 range down. If any range does not provide the proper indication, rezero the 4300 and perform the steps above for the range(s) that fail. The unit should be rezeroed just before calibrating ranges 1 or 2.

NOTE

If calibration is to be checked but not modified, use Table 6-204, which is somewhat wider in tolerance to accommodate the typical variation in 2500's.

TABLE 6-204.
DC VERIFICATION TOLERANCE

Range	Tolerance
0	+/- 150 Counts
1	30
2	10
3	10
4	10
5	10
6B	10

23. Press: SHIFT, SET RANGE, 5, ENTER. Set the 2500 to range 5 and note the reading. Now set the 2500 to range 4. The new reading should be one tenth the reading on range 5, within 2 counts. If not, perform the calibration again. Example: Range 5 = 6637 and range 4 = 662. One tenth of 6637 is 664 (round off). The range 4 value is one tenth of this.

24. Press AUTO RANGE. Note: If any of the ranges are to be calibrated again, be sure the instrument is in autorange mode.

25. Press SPECIAL, 3, ENTER. This puts the 4300 in the DC Edit mode where the DC gain constants can be read and recorded. Press ENTER to advance to each range, and record the gain factors. The last number on the display is the ADZERO value. Record this also. Write the numbers on a label and slide the label between the boards onto the shield, or keep the data in the envelope under the 4300 cover. Press ESCAPE and dBm to get back into dBm mode.

This completes the calibration of the input channel. Set the bit switch on the input board to that shown in Table 6-205, depending on the type of input channel. Set the Bit switch on the Control Board to all zero's or as desired, to protect the calibration and sensor data. See Table 6-202.

TABLE 6-205. NORMAL CHANNEL BIT SWITCH SETTINGS

	Universal	Thermal
1	Closed	Closed
2	Closed	Closed
3	Closed	Closed
4	Closed	Open

6-205. 30 MHz CALIBRATOR ADJUSTMENTS. The 30 MHz Calibrator is calibrated in the 4300 frame, using commands from the keyboard. Calibration data is stored in nonvolatile RAM on the 30 MHz Digital board. The Digital board and the 30 MHz Generator casting therefore constitute a pair and, if removed or replaced, must remain together.

There are two methods of calibration, both of which are described below. The first uses an external reference that can be adjusted from -60 to +20 dBm, and the technique is that of matching the 4300 calibrator to the reference. The second method uses a single level reference at 0 dBm, and fixed calibrated attenuators. The 0 dBm reference can be either a source, which the 4300 calibrator is matched to, or a meter, which measures the output of the 4300 calibrator. The "meter" approach is described here using the Wandel Golterman EPM-1 because of its good performance.

Early versions of the software (C* and earlier) require calibration of the -60 dBm point, as described below. In later versions, the -60 dBm point is extrapolated from the adjustment at -50 dBm. This eliminates the need for a 30 MHz amplifier. Contact Boonton for the procedure to update the software if desired.

6-206. METHOD 1, (VARIABLE REFERENCE METHOD):

1. Remove the top cover of the 4300 and the aluminum shield on the left side of the instrument. Remove the extender card as required to gain access to the control board switch. Set the Bit switches as follows:

Control Board	Input Channels	Rear Panel
1 Off 2 On 3 On 4 Off	Leave as is, see section on Input channel adjustments	All Closed

2. Solder a jumper on the 30 MHz Digital Board (at the extreme right of the 4300), between E1 and E2. These test points are accessible without removing the 30 MHz generator if care is used. This unprotects the nonvolatile RAM and allows calibration.

3. Set the calibrator to 0 dBm by pressing LEVEL, 0, ENTER (the shift key need not be pressed for number entries). Let the instrument warm up for 30 minutes.

4. Press RECALL, 0, ENTER. This puts the 4300 in a standard configuration (serves as an initialization) and sets it to channel 1. Any of the six channels can be used for this procedure, by selecting it from the front panel.

5. Connect a 51051 sensor to the channel 1 sensor input. (A 51013 sensor may be used with reduced accuracy.) Enter the sensor number (1-20) and type, and assign it to channel 1 (or the channel that is to be used). See the Operations Section for the sensor entry procedure. If a sensor is already entered into the instrument and assigned to a channel, reassign it to the same channel by setting the channel, then by pressing ASSIGN, N, ENTER, where N is the sensor number (1-20). This erases previous autocalibration data for that channel/sensor which may be invalid.

6. Press ZERO and wait for the zero cycle to complete. (The unit should be zeroed every few minutes or so, when making low level measurements.)

8. Connect the equipment as shown in Figure 6-202 and switch the coaxial switch to the 4300 calibrator. Cables should not be used between the calibrator and the sensors. Use rigid 90 degree couplers. The amplifier gain

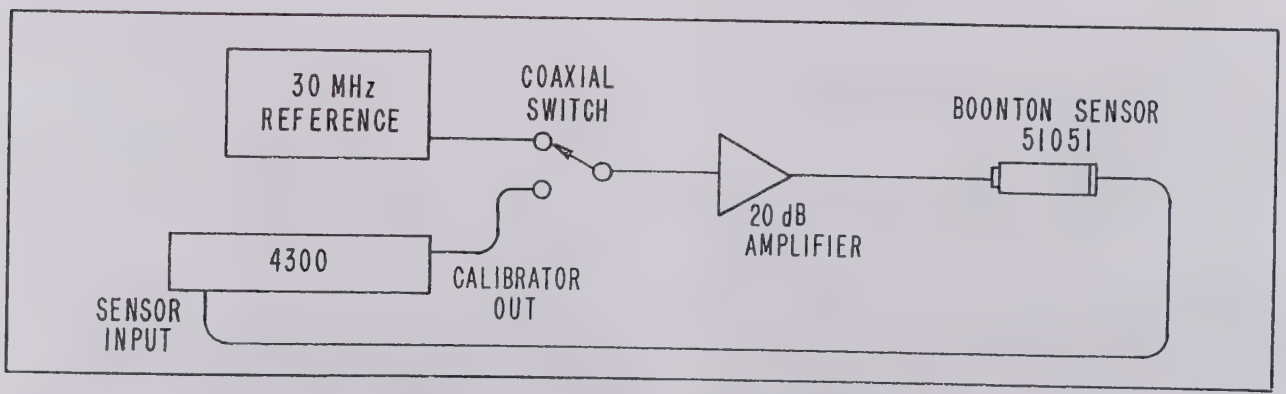

Figure 6-202. Calibration at 30 MHz Below 0 dBm

is not important since it is used for comparison of two measurements only.

NOTE

The amplifier is not required on units with the later software (D* and later).

9. Press the keys as shown below:

FILTER, 800, ENTER — (Selects 0.8 second filter)

SPECIAL, 8, ENTER — (Selects the raw data mode for greater resolution)

SPECIAL, 1, ENTER, 2, ENTER — (Selects settled reading mode)

SPECIAL, 6, ENTER — (Selects 30 MHz calibration routine)

10. CALENDAR ENTRY: Enter the month (1 to 12) as prompted by the display and press ENTER. Then enter the year (2 digits). Then press the + key. This starts the input channel measuring. The calendar dates are prompted only the first time the unit is powered up; if a unit is powered up twice in a row, the calibration is still valid but the dates are not entered the second time.

11. PEAKING: The calibrator is now set to about +3 dBm with the control loop saturated. Adjust C12 for a maximum reading on the meter. Note: To gain access to C12, input channels 5 and 6 have to be removed. If the calibrator is installed in the rear output, access cannot be obtained without removing the calibrator. Generally, C12 need not be adjusted, only when repairs have been made to the section near C12. If necessary, the calibrator may be calibrated with the Generator Section (casting) physically out of the 4300, still connected with the ribbon cable. An additional ground wire to the 4300 chassis will be necessary, connected by lifting screws on both the 4300 and the generator housing. This is necessary to prevent DC drops from adding to the control voltage. When the output has been peaked, press ENTER.

The calibrator is now set to -60 dBm (-50 dBm with the later software). Each 10 dB step is adjusted individually. Adjusting is done with 6 keys as shown (the shift key need not be pressed):

+	Increases output by about .003 dB
-	Decreases output by about .003 dB
•	Increases output by about .03 dB
0	Decreases output by about .03 dB
4	Increases output by about 0.3 dB
1	Decreases output by about 0.3 dB
ESCAPE	Returns the 4300 to measurement mode (can be done at any time)

12. -60 dBm AJUSTMENT (Not required with the later software): With the coaxial switch positioned to the reference, set the reference to -60 dBm and note the reading on the display and the range. Then turn the coaxial switch to the 4300 calibrator and adjust the level by using the keys as listed above so that the readings are the same. Switch back and forth between the 4300 and the reference as required. Note: Not only must the raw data reading match, but the range as well, because it is possible to be off by as much as one range and still have the raw data match. When the readings match, press ENTER. This enters the calibration data for that level and advances the calibrator to the next 10 dB step (-50 dBm).

NOTE

If it is desired to bypass a certain range without writing over the old calibration data, press SHIFT when on that range. When the desired range is reached, press + to start the input board measuring. If ENTER is pressed instead of SHIFT, the calibration data for that range will be erased, if the + key was not pressed.

13. -50 ADJUSTMENT: Set the reference to -50 dBm and switch the coaxial switch to the reference. Take a reading as described in the -60 dBm adjustment above and then adjust this range. Each time a new range is selected, the + key must be pressed to begin measurement. See the note above regarding range skipping.

14. -40 dBm to +10 dBm ADJUSTMENTS: Remove the amplifier from the path if it was installed (early software versions only). Progressively adjust each 10 dB step as in previous steps, up to +10 dBm. Leave the unit on the +20 dBm range.

15. +20 dBm ADJUSTMENT: Insert a 10 dB attenuator in series with the sensor as shown in Figure 6-203. Adjust this range as done for other ranges, and press ENTER as the last step, to store the calibration results. The 4300 will exit from the calibration routine as this is the last point.

16. DOWNSCALE ADJUSTMENT: The instrument should still be in the raw value mode and in the settled reading mode. Set up the equipment as shown in Figure 6-202, but do not use the amplifier. Set the 4300 and the reference to -20 dBm. Compare readings of both by alternating the coaxial switch. If they are more than two counts different, do the calibration above again.

Now set both units to -29 dBm. Adjust the pot R11 on the top of the 30 MHz Generator assembly (casting) so that the readings match. If the Generator is assembled into the 4300 for a rear output, this pot is accessible only by removing the Generator. The generator should be mounted in the front output position temporarily with the two screws on the bottom to obtain a good ground.

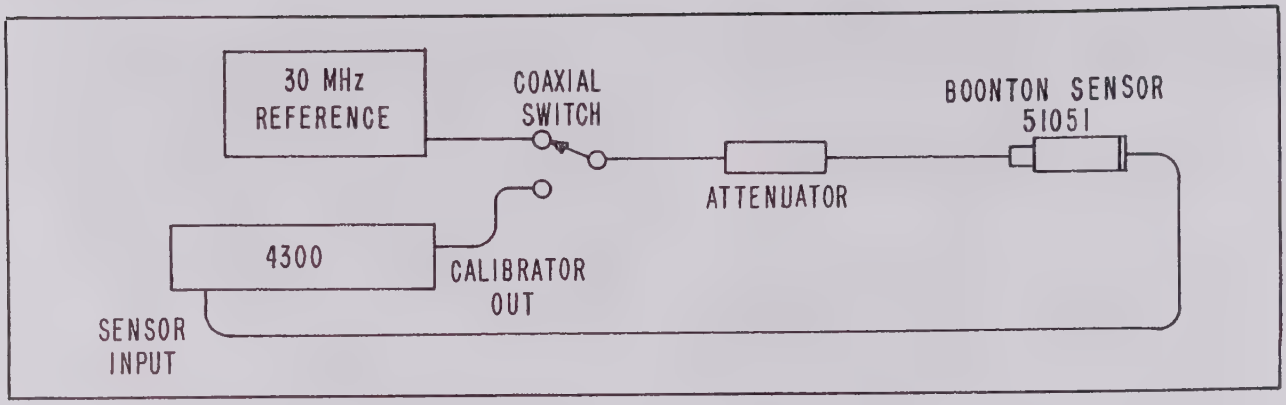

Figure 6-203. Calibration at 30 MHz Above 10 dBm

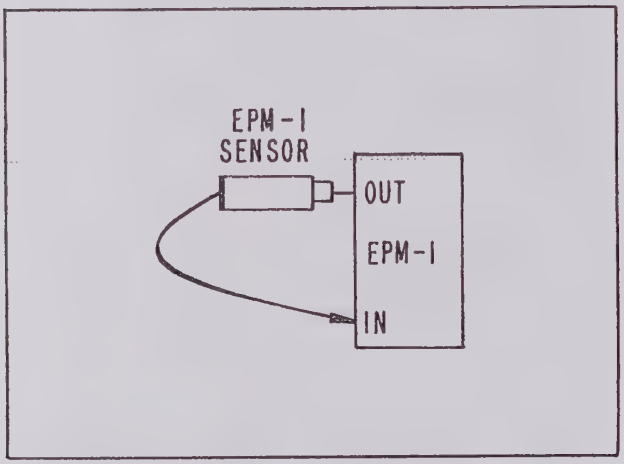

Figure 6-204. Zeroing the EPM-1

NOTE

A downscale adjustment that is more than 1/8 of a turn will in general change the upscale calibration. On a unit that has just been repaired, the best way to calibrate is to skip by the lower range adjustments and do a downscale adjustment first, then go back and adjust each range.

17. UPSCALE CHECK: Set the 4300 and the reference to -20 dBm. Press dBm. Compare readings again in dBm. If there is more than .01 dB difference, recalibrate the 10 dB steps again.

18. CENTER POINT CHECK: Set the 4300 and the reference to -25 dBm. Compare readings again. If there is more than .02 dB difference, the unit must be troubleshooted.

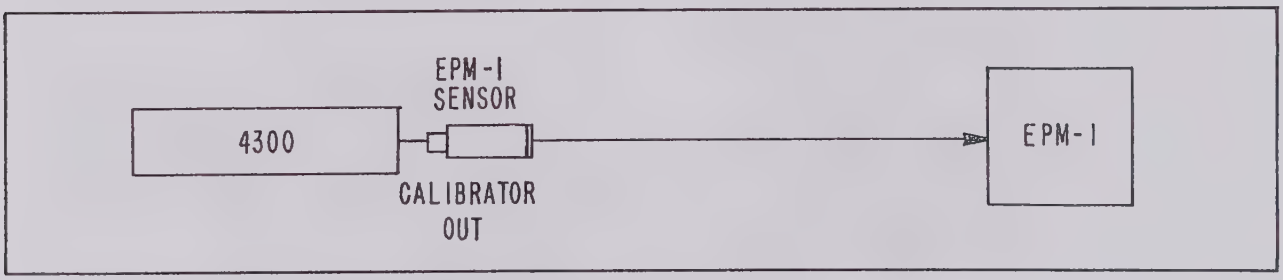

Figure 6-205. 0 dBm Measurement

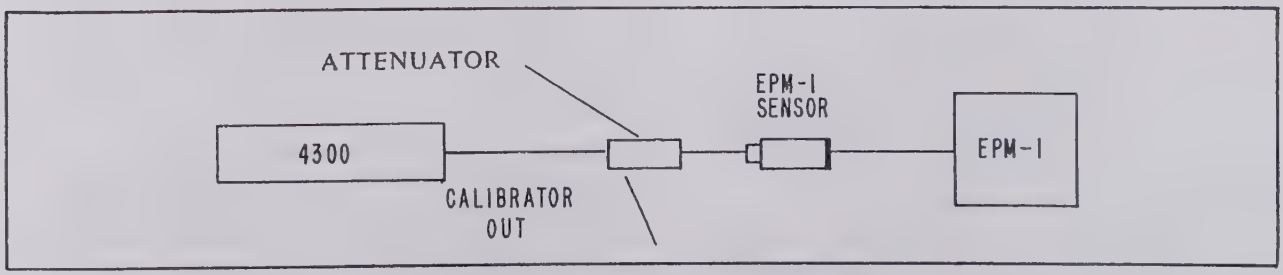

Figure 6-206. Attenuated Measurements

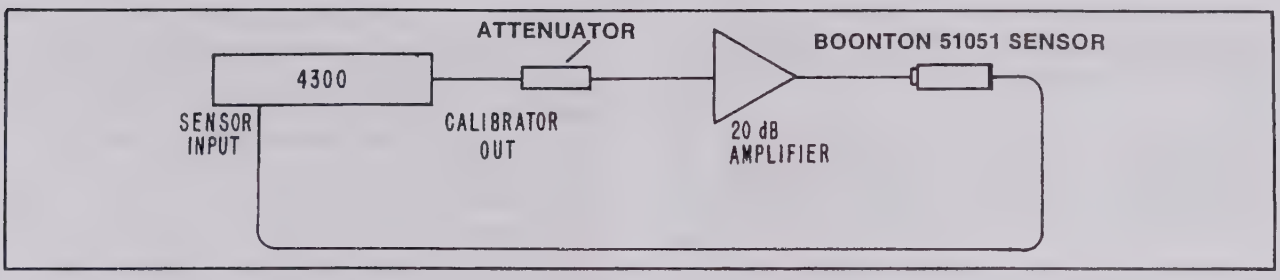

Figure 6-207. Measurement at -60 dBm

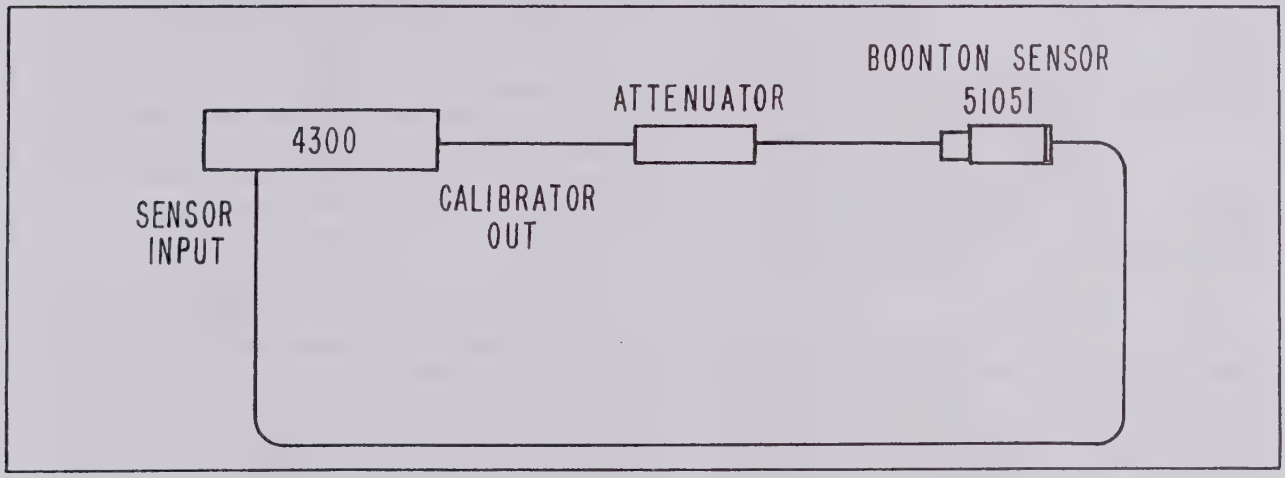

Figure 6-208. Wraparound Measurement

19. FINAL CHECK: Power down the 4300 and wait a fewseconds, then power up. Press SHIFT, CALIBRATOR LIMIT, 20, ENTER. Using the Calibrator LEVEL key, and SHIFT and ENTER, take readings on both the 4300 and the reference at 5 dB intervals from -60 to +20 dBm. Use the 10 dB attenuator when taking measurements above +10 dBm. When checking points at or below -40 dBm, be sure to zero the 4300 ever few minutes. Use the amplifier for checking the -60 dBm point (early software). If any reading differs by more than .02 dB, recalibrate the unit.

20. JUMPER: Disconnect the jumper on the Digital board if it is desired to protect the unit from accidental recalibration. Set the control board Bit switch to all zeros, or as desired, see Table 6-202. This concludes the adjustment of the 30 MHz Calibrator, method 1.

6-207. METHOD 2, (FIXED ATTENUATOR METHOD):

1. This method uses a Wandel Goltermann milliwatt test set to set the 0 dBm level, and fixed attenuators such as Weinschel Model 1's. The EPM-1 is traceable to the German National Physics Lab, with a basic accuracy at 0 dBm of +/- .015 dB. Alternatively, an HP432A power meter may be used along with a DVM instead of the EPM-1. The HP478A-H55 and HP478-H75 power head calibrations are traceable to NBS. In this case refer to the HP432 instructions for "Precision Power Measurements", and substitute the HP432 for the EPM-1 in the steps below.

2. ATTENUATOR CALIBRATION: If the exact attenuation of the pads is not known, they can be measured at DC. The DC attenuation is extremely close to the attenuation at 30 MHz, since the type N attenuators are being used at about 0.2% of their maximum frequency. Alternatively, the attenuators may be sent to NBS for certification at 30 MHz. To make the measurement, connect a stable DC source through two series 50 ohm resistors to ground. Type N connectors and soldered joints are essential to keep the ground offsets low. Adjust the center point voltage of the resistors for about 2V, and record as V1. Now connect the attenuator under test between the resistors, and measure the voltage at the output of the attenuator (V2). Calculate ATTEN = 20 log (V2/V1). The tolerance of the 50 ohm resistors does not affect the accuracy of this measurement on a first order approximation since the initial voltage was measured taking their actual values into account. The linearity of the voltmeter is important for this test.

3. PROCEDURE: Remove the top cover of the 4300 and perform the steps shown in Method 1 above, (up to the - 50 dBm adjustment), except do not connect the equipment.

4. Connect the equipment as shown in Figure 6-204. On the EPM-1, set the range switch to 0 dBm, and the resistance switch to 50 ohms. Adjust the calibration control on the EPM-1 for a null (0 dBm) indication.

The calibrator is now set to -60 dBm (-50 dBm for the later software version). Each 10 dB step is adjusted individually. Adjusting is done with 6 keys as shown (the shift key need not be pressed):

+	Increases output by about .003 dB
-	Decreases output by about .003 dB
.	Increases output by about .03 dB
0	Decreases output by about .03 dB
4	Increases output by about 0.3 dB
1	Decreases output by about 0.3 dB
ESCAPE	Returns the 4300 to measurement mode (can be done at any time)

5. 0 dBm ADJUSTMENT: Press SHIFT until the unit scrolls to the 0 dBm range. Then connect the equipment as shown in Figure 6-205. Note: The EPM-1 is sensitive to overloads above about 1 dBm; be sure the calibrator is set correctly before connecting. Now press the 6 keys as listed above to adjust the calibrator to exactly 0 dBm. Then press ENTER once, and ESCAPE.

6. +10 dBm ADJUSTMENT: With the EPM-1 disconnected from the calibrator, press SPECIAL, 6, ENTER. Press SHIFT until the instrument is on the +10 dBm range. Connect the equipment as shown in Figure 6-204 and zero the EPM-1. Then connect the equipment as shown in Figure 6-206 using the 10 dB attenuator. Adjust the level using the six keys listed in previous secitons until the reading on the EPM-1 is 10.00 - ATTEN, where ATTEN is the attenuation of the fixed attenuator. (The range switch on the EPM-1 may have to be used; the range switch setting gets added to the meter reading.) Press ENTER once, and ESCAPE.

7. +20 dBm ADJUSTMENT: With the EPM-1 discon nected from the calibrator, press SPECIAL, 6, ENTER. Press SHIFT until the instrument is on the +20 dBm range. Then connect the equipment as shown in Figure 6-206 using the 20 dB attenuator. Adjust the level using the six keys listed in previous secitons until the reading on the EPM-1 is 20.00 - ATTEN. (The range switch on the EPM-1 may have to be used; the range switch setting gets added to the meter reading). Press ENTER once, and ESCAPE.

NOTE

During calibration at levels above +10 dBm, the calibrator limit function does not affect (limit) the output, but when SPECIAL 6 is exited and the calibrator is to be checked, the calibrator limit must be set to +20 dBm. See the CALIBRATOR LIMIT key in the operating section.

8. DOWNSCALE ADJUSTMENT: Connect the equipment as shown in Figure 6-206, using the 1 dB attenuator. Press ESCAPE to leave the calibration routine. Press LEVEL, 1, ENTER. Adjust the pot R11 on the top of the 30 MHz Generator assembly (casting) so that the reading on the EMP-1 is equal to 1.00 - ATTEN where ATTEN is the exact attenuation of the attenuator. If the Generator is assembled into the 4300 for a rear output, this pot is accessible only by removing the Generator. The generator should be mounted in the front output position temporarily with the two screws on the bottom to obtain a good ground.

9. -60 dBm ADJUSTMENT (Early software only): Connect the equipment as shown in Figure 6-207, using the 60 dB attenuator or stacked attenuators equal to 60 dB nominal. Cables should not be used between the calibrator and the sensors. The amplifier gain is not important since it is used for comparison of two measurements only. Press LEVEL, 0, ENTER. Take a reading and call it A. Now set the level to -60 dBm (LEVEL, 60, -, ENTER). and remove the attenuator from the path. Press SPECIAL, 6, ENTER to get into the calibration routine. Press + to begin measurement, and adjust the level using the six keys previously mentioned so that the reading is equal to A + ATTEN + (-60). For example,

Reading A	=	-40.45
ATTEN	=	+ 60.40
Desired Level	=	-60.00
Adjust for		-40.05 dBm

Then press ENTER once, and ESCAPE.

10. -50 dBm ADJUSTMENT: Connect the equipment as shown in Figure 6-208 and perform this calibration the same as the -60 dBm adjustment, using the 50 dB attenuator and setting the calibrator to -50 dBm. When SPECIAL 6 is executed, it will be necessary to skip over the -60 dBm range by pressing SHIFT (early software only). If ENTER is pressed instead, the -60 dBm calibration will be erased.

11. -40 dBm to -10 dBm ADJUSTMENTS: Perform these range adjustments the same as above, in order. Press ENTER when the -10 dBm point is completed, then ESCAPE.

12. Perform the "Final Check" as outlined in method 1 above.

13. JUMPER: Disconnect the jumper on the Digital board if it is desired to protect the unit from accidental recalibration. Set the control board Bit switch to all zeros, or as desired, see Table 6-202. This concludes the adjustment of the 30 MHz Calibrator, method 2.

6-208. 50 MHz CALIBRATOR ADJUSTMENT. The 50 MHz 0 dBm calibrator is calibrated using a Wandel Goltermann EPM-1 Milliwatt Test Set. Alternatively, an HP432 Analog Power Meter can be used in conjunction with a digital voltmeter and an NBS traceable power head. In this case, refer to the HP432 manual for "precision power measurements", and replace the EPM-1 in the procedures below with the HP432.

The adjustment pot for the 50 MHz calibrator is in the top of the 4300 if it is installed in the front output connector, and on the bottom if mounted in the rear output connector.

The procedure is as follows:

1. Warm up the equipment for 30 minutes. Connect the EPM-1 power head to the EPM-1 input port, and connect the thermistor power head RF port to the 0 dBm output on the EPM—1. Follow the manufacturers instructions for setting up the instrument as necessary. Adjust the front panel potentiometer for a 0 dBm indication on the analog meter.

2. Disconnect the RF port of the power head from the EPM-1 and connect it to the 4300 50 MHz output. Observe the analog meter. Adjust R4 on the 50 MHz calibrator for a 0 dBm indication.

3. Measure the output frequency of the 50 MHz calibrator; it should be 50 +/- 0.5 MHz.

If either the level or the frequency cannot be adjusted within spec, follow the steps below.

4. Remove the calibrator from the 4300 and leave it connected to the power supply. Remove the cover from the calibrator and power up. Monitor pin 3 of the op amp with a scope of DC voltmeter and adjust R4 for approximately -4 VDC. With the RF port terminated into a 50 ohm load (such as the frequency counter), monitor the junction of L3 and R15 with a scope. Adjust C4 and C12 for 600 mkV p-p at 50 MHz. The controls may be interacting.

5. Replace the cover and put the calibrator back into the 4300. Connect the EPM-1 power head to the calibrator. Readjust R4 for a 0 dBm indication.

6-209. DC CAL FACTOR ENTRY AND EDIT. After repairs have been made on the input channels, or a soft error has occured due to inadvertent shorting, a reset of the input channel is necessary and the DC calibration factors that are printed on the channel module must be re-entered. Alternatively, the module can be recalibrated. If any modifications/repairs have been made to the input amplifiers or A/D, recalibration is necessary; see Input Channel Adjustments. The entry procedure of the old data is as shown below.

Go to single channel mode and select the approprate channel. Note the numbers on the label and enter according to the keystrokes below. Note: ranges 0 and 1 use the same data points.

Press	The Display Will Show
SPECIAL, 3, ENTER	Range 0 and DC CAL nnnn
(4 digit number for range 0), ENTER	Range 1 and DC CAL nnnn

Continue for each range. The enter the ADZERO number with the same procedure. The 4300 will escape and return to measurement mode.

6-210. SENSOR DATA ENTRY. Part of the overall 4300 adjustments include the entry of sensor serial number, type, linearity data and high frequency calibration data. Refer to the operating section for the sensor entry procedure, and enter or check the data as required for each sensor. For the case of coaxial sensors, when the 30 MHz Programmable Calibrator is installed, the linearity data need not be entered, but instead the Autocalibration cycle should be executed.

6-211. AUTOCALIBRATION. Also included as part of overall adjustments is the autocalibration cycle, which applies to coaxial sensors when the 30 MHz programmable calibrator is installed. The calibration is a final step after the sensor assignments have been done, since channel errors are also nulled out and stored on the channel with this procedure. Sensor re-assignment erases this data. Refer to the CALIBRATOR AUTOÇAL key in the Operation Section for the procedure and perform it for each of the coaxial sensors.

6-212. AC REFERENCE FREQUENCY CALIBRATION. When there is no programmable calibrator installed, the sensor must be calibrated for linearity at some reference frequency, generally at 1 MHz for coaxial sensors. The calibration is done by modifying the 14 point linearity data stored in the sensor data bank. The data supplied with the sensor can be used, however if this data is suspect or it is desired to recalibrate using a known AC source, the procedure below should be followed. This also applies to millimeter wave sensors which cannot be used with the programmable calibrator.

The 14 point data involves a gain correction number for each of the 7 ranges (from 4200 to 5800) which is calculated based on a measurement near the top of each range (upscale correction). Then there is an offset which is calculated at about 1/4 of full scale (downscale correction). See Section 4 for the theory of use of these num-

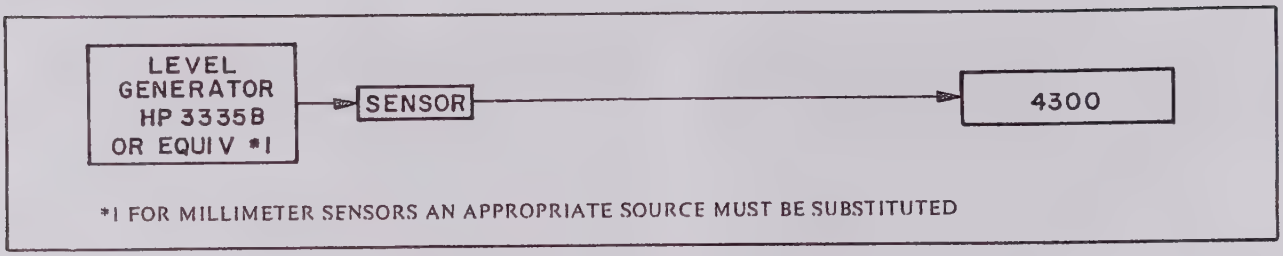

Figure 6-209. Basic Reference Frequency Calibration

bers. After calculation of these numbers, they are entered into the sensor data bank using the SENSOR ENTRY key, as shown below.

For the 51015 and 51033 sensors, which go up to +30 and +33 dBm respectively, the 30 MHz internal calibrator does not calibrate to the top end, but rather extrapolates. The extrapolation error is perhaps .04 dB; this 14 point calibration procedure will correct for this, and autocalibration can still be used, which is applied on top of the 14 point calibration. However, the accuracy of the sensors is reduced at the higher levels anyway, at medium and high frequencies, so the extrapolation error is not a large contributor of error. The procedure for Reference Frequency Calibration is shown below:

1. **Initialization.** Power up the equipment and let it warm up for 30 minutes. Connect the equipment as shown in Figure 6-209. Use no cables between the sensor and the generator. Set the Bit switch on the 4300 rear panel, position 6, to closed, and set the internal Bit switch (on the control board), position 3, to "on". See Table 6-202 and Figure 6-201 for the Bit switch functions.This unprotects the sensor data and allows modification from the front panel.

Set the 4300 to a standard configuration by pressing SHIFT, RECALL, 0, ENTER. Then set the channel to be used for calibration (not necessarily the one to be used in the final application) by pressing SHIFT, SET CH, N, ENTER, where N is the channel (1-6).

Enter the sensor type and serial number into one of the sensors, 1 to 20, if not done already, by pressing SENSOR ENTRY, M, ENTER, where M is the sensor number (1-20). Then follow the prompts and press ESCAPE after the serial number has been entered. The upscale and downscale data can be left as their old values, if previously entered, or may be left as zeros, or set to 0 (downscale) and 5000 (upscale). See the Sensor Entry key in the Operations Section for more detail.

Assign the sensor to the channel by pressing SENSOR ASSIGN, N, ENTER, where N is the sensor number.

2. **Attenuator Calibration.** If the exact attenuation of the pads is not known, they can be measured at DC. The DC attenuation is extremely close to the attenuation at 30 MHz, since the type N attenuators are being used at about 0.2% of their maximum frequency. Alternatively, the pads may be sent to NBS for certification at 30 MHz. To make the measurement, connect a stable DC source through two series 50 ohm resistors to ground. Type N connectors and soldered joints are essential to keep the ground offsets low. Adjust the center point voltage of the resistors for about 2V and record as V1. Now connect the pad under test between the resistors, and measure the voltage at the output of the pad (V2). Calculate ATTEN = 20 log (V2/V1). The tolerance of the 50 ohm resistors does not affect the accuracy of this measurement on a first order approximation since the initial voltage was measured taking their actual values into account.

3. **Reference Frequency Setting.** Set the level generator to 1 MHz for coaxial diode sensors, and 10 MHz for thermal sensors. (Any frequency in the sensor's range below 1 GHz can serve as a reference for calibration, as long as an amplifier is available at that frequency, or as long as the source can go up to the top of the sensor's range. The sensors are extremely flat over frequency below 1 GHz so the frequency of calibration is not important). For millimeter wave sensors, set the level generator to that shown in Table 6-206.

TABLE 6-206. WAVEGUIDE REFERENCE FREQUENCIES

Sensor	Reference Frequency
51035	22 GHz
51036	33
51972	33
51037	40
51045	40
51046	60
51047	94

4. **Upscale Calibration.** With no power applied to the sensor, press ZERO and wait for the zero cycle to complete (zeroing should be done once a minute or so when calibrating on ranges 1 and 2).

Set the level generator to those levels shown in Table 6-207. Upscale calibration points, according to the

sensor type. Start from the lowest power and proceed until the level generator in use can no longer supply the proper level (the higher levels are done with the amplifier in the steps below). For each point, verify that the channel is on the proper range, and if not, set it using the RANGE SET key. Take readings in dBm and for each point, calculate the change to be added to the upscale gain factor by:

Upscale Change = (Upscale Calibration Point – Actual reading) x 172.

TABLE 6-207. UPSCALE AND DOWNSCALE CALIBRATION POINTS

Sensor	Range	Upscale Cal Point	Downscale Cal Point
51010,	1	–44 dBm	–50 dBm
51011,	2	–34	–40
51012,	3	–24	–30
51013	4	–14	–20
	5	0	–10
	6	16	6
51015	1	–34	–40
	2	–24	–30
	3	–14	–20
	4	–4	–10
	5	10	0
	6	26	16
51033	1	–24	–30
	2	–14	–20
	3	–4	–10
	4	6	0
	5	20	10
	6	30	26
51016	1	–10	–16
	2	0	–6
	3	10	4
	(Ranges 4 through 6 not used)		
51017	1	0	–6
	2	10	4
	3	20	14
	(Ranges 4 through 6 not used)		
51051	0	–53	–58
	1	–43	–48
	2	–33	–38
	3	–23	–28
	4	–12	–18
	5	3	–5
	6	10	6
51035	1	–45	–50
	2	–34	–40
	3	–24	–30
	4	–12	–20
	5	0	–8
	6	10	4

TABLE 6-207. UPSCALE AND DOWNSCALE CALIBRATION POINTS (Cont.)

Sensor	Range	Upscale Cal Point	Downscale Cal Point
51036,	2	–44	–50
51972	3	–34	–38
	4	–20	–28
	5	–10	–16
	6	10	–4
51037	2	–44	–50
	3	–34	–38
	4	–20	–28
	5	–10	–18
	6	10	0
51045	2	–38	–44
	3	–28	–35
	4	–16	–25
	5	–4	–13
	6	10	0
51046	1	–46	–50
	2	–34	–41
	3	–24	–31
	4	–12	–20
	5	0	–8
	6	10	3
51047	1	–45	–49
	2	–35	–42
	3	–24	–32
	4	–13	–21
	5	–2	–10
	6	10	1

For example, if the generator output is set to an upscale point of –10.00 dBm and the actual reading is –10.15, the upscale gain factor will have to be changed by 0.15 x 172 counts. The reading is low so the count will have to be in the positive direction. Take all the readings first, then change all the upscale factors at once, as follows:

To change the factors, press the SENSOR ENTRY key and scroll through the sensor number and serial number by pressing ENTER repeatedly, to get access to the upscale factors. When the range 0 number is reached, mentally modify the number on the display by the change calculated above and enter the new number.

NOTE:

Range 0 and range 1 use the same upscale factor, derived from a reading on range 1. A zero in the upscale number is to be interpreted as a 5000. Some of the waveguide sensors are not measured on either ranges 0 or 1, but use the gain correction derived from the measurement on the range 2 for these ranges. Table 6-207 gives this information.

For example, in the case above, suppose that the upscale on range 1 was 4900 at the time of the initial measurement. The new number is 4900 + 172 or 5072, which is entered at this time, on range 0 and 1. Terminate each entry with ENTER (not ENTRY), which advances the 4300 to the next range. Modify the factors for each range as required.

Press ESCAPE to return to the measurement mode and take the full scale readings again. If any readings are not correct, repeat the sequence. The readings will be closer each time.

5. **Downscale Calibration.** Remove the power from the sensor, wait 10 seconds or so for the sensor to settle, and press ZERO and wait for the zero cycle to complete.

With the equipment still connected as shown in Figure 6-209, set the level generator to those listed in Table 6-207, Downscale Calibration Points, and take readings in dBm, on calibration points as far up as the generator will go, but not above the highest range that was calibrated for upscale (the upscale on each range must be done before the downscale). Verify that the channel is on the proper range for each point, and if not, set it using the RANGE SET key. For each point, calculate the change to be added to the downscale factor by:

Downscale Change = (Downscale Calibration Point - Actual Reading) x 23.

When all the downscale calibration points have been measured, press the SENSOR ENTRY key and change the downscale factor on each range by the appropriate amount, as was done for the upscale factors. As for the upscale points, range 0 should use the same data as range 1, and some of the waveguide sensors use the same point on ranges 0, 1, and 2.

Press ESCAPE to return to the measurement mode, and take the downscale readings again. In general, these downscale points will have to be adjusted several times until they are correct, because the formula above is only approximate and varies from sensor to sensor. The downscale calibration procedure is thus one of successive approximation.

6. **Upscale Calibration With The Amplifier.** The calibration points that were above the generator limitation are calibrated with the procedure below. Connect equipment as shown in Figure 6-210. Turn off the source and let the sensor settle for 20 seconds. Press ZERO and wait for the 4300 to complete its zeroing cycle.

Starting from the lowest upscale calibration point in Table 6-207 that could not be calibrated without the amplifier (if any), calibrate these points as shown below.

Set the level generator so that the 4300 reads approximately the given calibration point minus 20 dB. For example, in Table 6-207 if it calls out to be calibrated at +18 dBm and the generator only goes to +13 dBm, set the generator so that the 4300 reads as close to (18 - 20) or -2 dBm as possible. Take a reading and call it A.

Disable the source and remove the attenuator, to agree with the configuration shown in Figure 6-211. Do not use a cable between the sensor and the amplifier. Enable

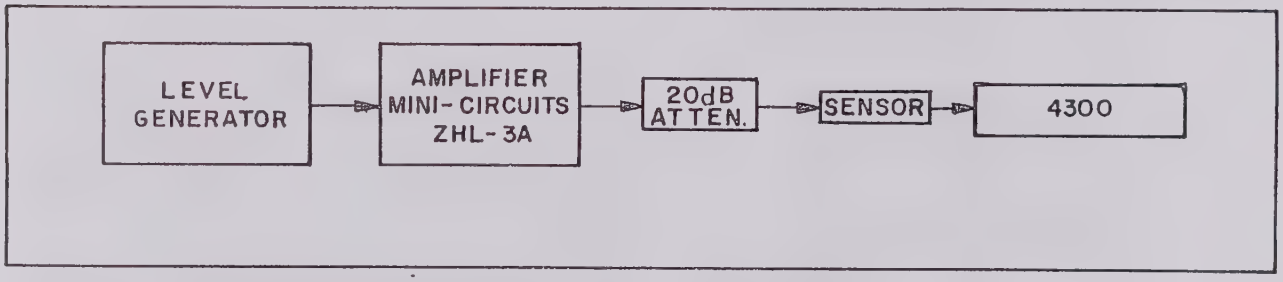

Figure 6-210. High Level Reference Frequency Calibration, Step 1

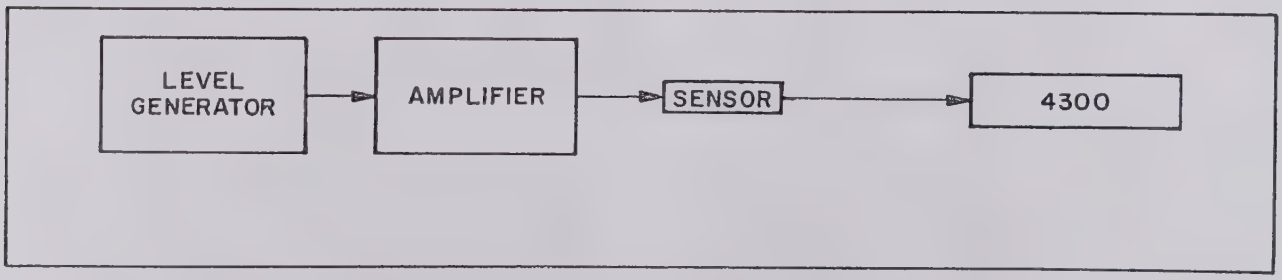

Figure 6-211. High Level Reference Frequency Calibration, Step 2

the source. Now the power will be roughly +18 dBm, in this example, per the requirement. The exact power in general will be:

Amplifier Output = A + ATTEN

where the attenuation (ATTEN) has been measured previously. The power need not be exactly equal to the upscale calibration point, but should be within +/– 1 dB, and it must be known, as calculated with the above equation.

Now, knowing that power, the 4300 is adjusted to read that power, using the upscale factor as before. The upscale factor is adjusted by an amount equal to:

Upscale Change = (Amplifier Output – Actual reading) x 172

where the amplifier output was calculated in the steps above.

Do this for each range that could not be calibrated without the amplifier, and then, back in measurement mode, check the readings to see that they match the calculated amplifier output(s). For each point, first set the level generator with the attenuator in the circuit, then remove it to take the measurement.

7. **Downscale Calibration With The Amplifier.** Turn off the source and let the sensor settle for 10 seconds. Press ZERO and wait for the 4300 to complete its zeroing cycle.

Starting from the lowest downscale calibration point in Table 6-207 that could not be calibrated without the amplifier (if any), calibrate these points as follows.

Connect the equipment as shown in Figure 6-210. Set the level generator so that the 4300 reads approximately the given calibration point minus 20 dB. For example, in Table 6-207 if it calls out to be calibrated at +15 dBm and the generator only goes to +13 dBm, set the generator so that the 4300 reads as close to (15 – 20) or –5 dBm as possible. Take a reading and call it B.

Disable the source and remove the attenuator, to agree with the configuration shown in Figure 6-211. Now, the power will be roughly +15 dBm, per the requirement. The exact power in general will be:

Amplifier Output = B + ATTEN

Now, knowing that power, the 4300 is adjusted to read that power, using the downscale factor as before. The downscale factor is adjusted by an amount equal to:

Downscale Change = (Amplifier Output – Actual reading) x 23,

where the amplifier output was calculated in previous steps.

Do this for each range that could not be calibrated without the amplifier, and then, back in measurement mode, check the readings to see that they match the calculated amplifier output(s). For each downscale point, first set the level generator with the attenuator in the circuit, then remove it to take the measurement. In general, the downscale points will have to be calibrated several times in succession.

This completes the AC referenc frequency calibration. If it is desired to protect the sensor data from accidental corruption, set either the control board Bit switch position 3 to zero, or set the rear panel Bit switch position 6 to OPEN, or both. Reassign the sensor to another channel as required for operation.

SECTION 6-300
TROUBLESHOOTING

6-301. ACCESS TO BOARDS.

Refer to Section 2, Installation, for information on removing boards and modules and gaining access to them.

6-302. GENERAL.

An instrument malfunction will generally be evident from the front panel. Or, the unit may not be able to be calibrated. If either of these conditions is present, first follow the steps below:

Initialize the instrument with a soft reset from the rear panel. See Table 6-202 and the section titled "Initializing Via the Bit Switches" in the Adjustments section for the procedure. This may correct problems that occurred due to memory dropouts.

If the soft reset does not correct the problem, perform a hard reset, as shown in the Adjustments Section. A hard reset may fix a condition that was caused by intermittent shorts etc., that caused a memory dropout. A hard reset will also erase all sensor calibration data and all instrument setups, so it should be done at the repairpersons discretion.

If a hard reset does not correct the problem, refer to the Theory of Operations section and then to the troubleshooting charts, figures 6-301, 6-302 and 6-303. Proceed to the test indicated according to the problem.

6-303. TEST 100 (POWER SUPPLY).

The power supply consists of voltage regulators A8U1, A8U2 and A8U3 on the heatsink assembly and various filter capacitors and resistors on the control board.

Check voltages on TP9, TP10 and TP12 for +5, +15 and -15 VDC, ±5%. TP11 is provided as a convenient ground point. Refer to the appropriate paragraph below for high or low voltage conditions. If the voltages are OK and the 4300 is still non-operating, proceed to TEST 101.

High voltage on any one (or more) of these TP may indicate a shorted regulator, an open resistor on the control board, or a shorted protection diode (CR2, CR6, CR7).

Low voltage on any one (or more) of these TP's may indicate a short somewhere in the frame. Remove all the channel modules and the 30 MHz calibrator. If the voltage comes up to normal, suspect one of the modules. Also, check for solder flakes, loose screws, etc., in the unit.

If the input voltages to the regulator are greater than 2 volts above the nominal regulated voltages and the output is still low, replace the regulator in question. If there is still a problem, check the resistors in the regulator region.

6-304. TEST 101 (POWER UP/RESET).

This circuitry provides the μP with non-maskable-interrupt (NMI-), HALT- and RESET- signals. When the line voltage is below limits set by potentiometer R9, all 3 signals should be low. During power up and down, they follow the sequence as shown on the control board schematic.

When powered up, proper operation is indicated when NMI-, RESET- and HALT- lines are logic high. Electrical 'noise' on any of these signal lines may cause the μP to respond erratically. The following conditions should be met:

1. Check for approximately 5.2 V at the junction of CR4 zener diode and resistor R16.

2. Using a variable AC power source, vary the line voltage from 75% to 100% of nominal and check at TP5 for NMI- toggling between logic zero and one. If not, replace U22.

3. With low line, check that TP6, (RESET-) and TP7, (HALT-) have also gone logic low. If not, replace U23. Also, reset R9 as outlined in the Adjustments section of this manual.

4. With nominal AC line, if HALT- is low and NMI- is high, this may indicate that the μP has halted due to stimulus from another source.

5. HALT- and RESET- should come up about ½ second after NMI-, during power up.

If the power up reset circuits appear to be OK and there is still a problem with the unit, proceed to TEST 102 (CLOCKS).

6-305. TEST 102 (CLOCKS).

The clock consists of a Y1, a crystal oscillator module with TTL compatible output, and U20, a binary counter. Clock signals are supplied throughout the instrument and failure would generally show up as a completely non-functional unit.

1. Check Y1 pin 8 for a 16 MHz square wave (62.5 ns period).

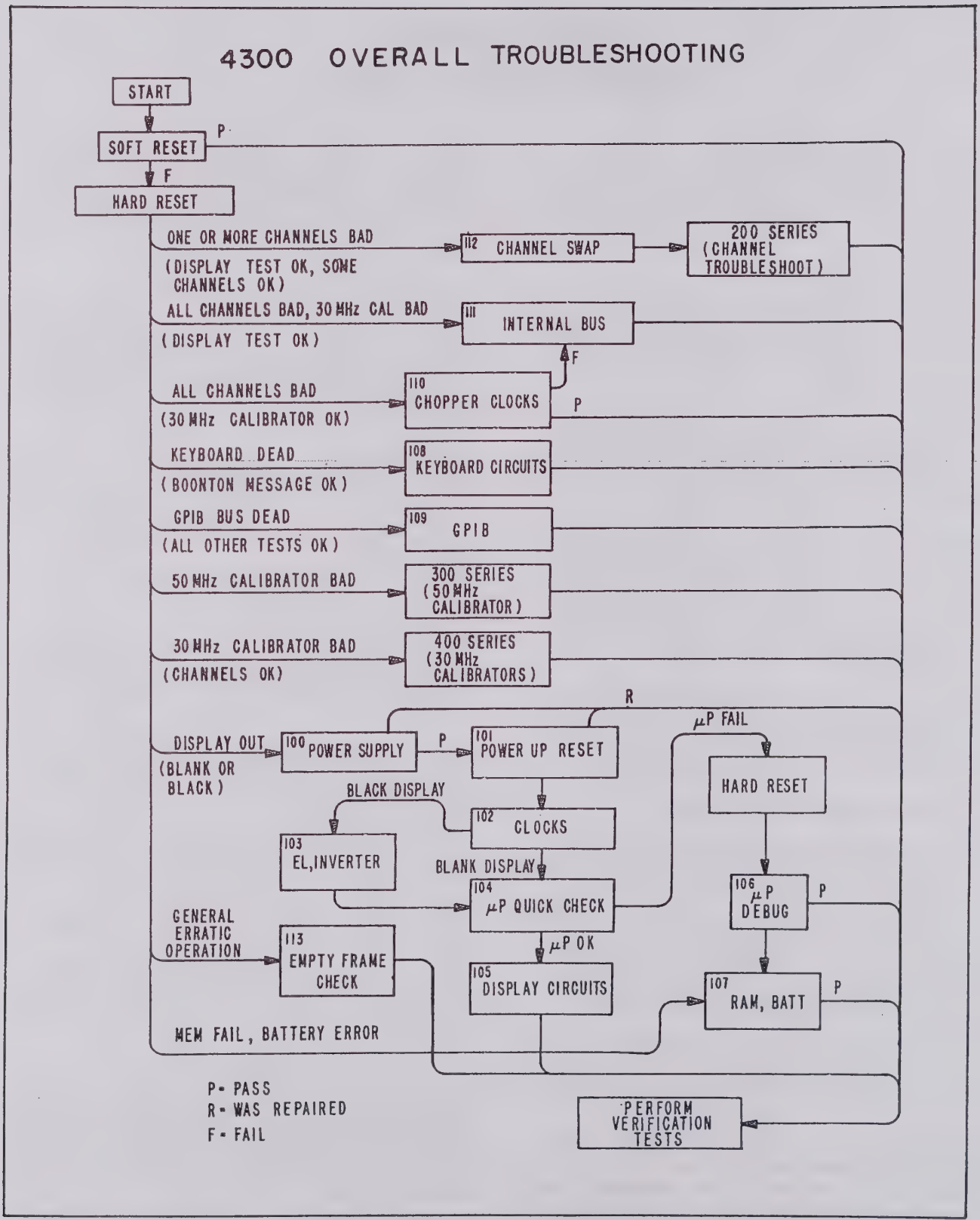

Figure 6-301. Overall Troubleshooting

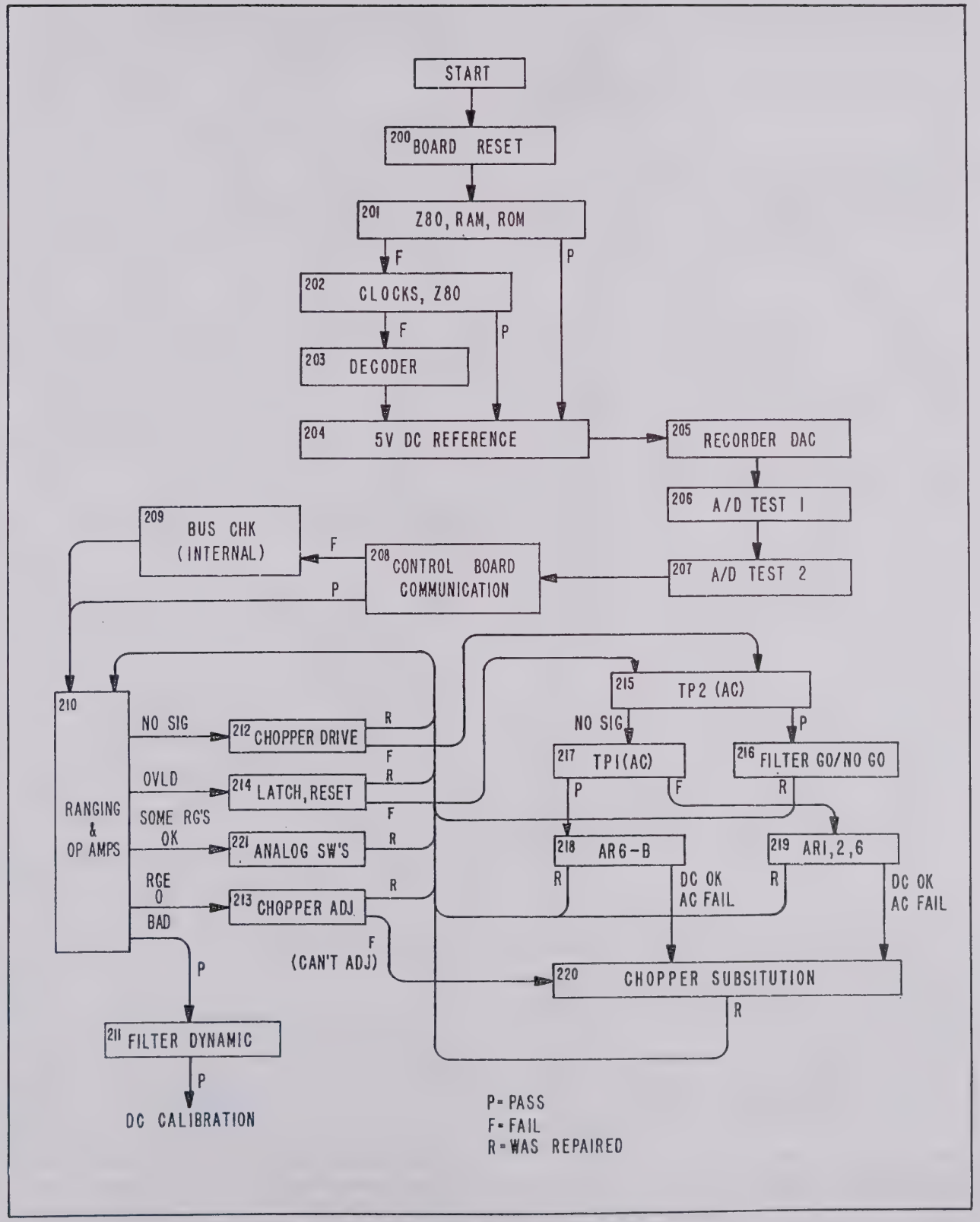

Figure 6-302. Input Channel Troubleshooting

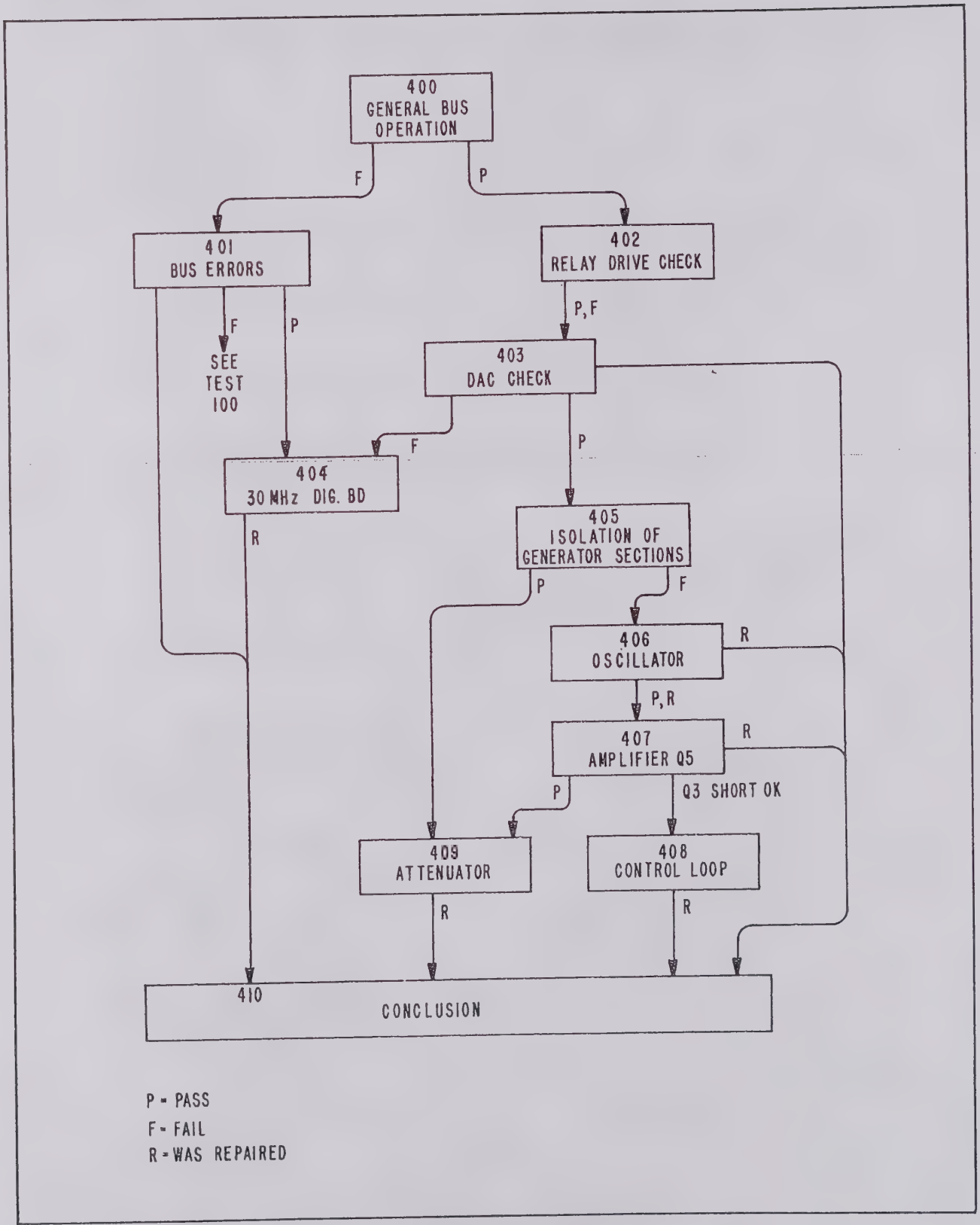

Figure 6-303. 30 MHz Calibrator Troubleshooting

2. Check U20 for a binary counting sequence on pins 14, 12, 8, 9 and 11 respectively. The frequencies encountered on these pins are 16 MHz (62.5 ns), 8 MHz (1.25 μs), 4 MHz (.250 μs, 2 MHz (.500 μs) and 1 MHz (1.00 μs) respectively.

3. Replace Y1 or U20 as necessary. If only one of the clock lines are bad, it may be due to a short.

4. If the clocks are OK and the display is out (black), proceed to TEST 103 (EL PANEL AND INVERTER). If the display is illuminated but incorrect (just blank squares for example) do TEST 104 (μP QUICK CHECK).

6-306. TEST 103 (EL PANEL & INVERTER).

If the display is black the problem may be the electroluminescent panel or the DC to AC inverter.

1. Remove the front panel of the instrument and look at the EL under the LCD. If there is no bluish light, check for 85 VAC at the EL panel terminals. Replace the inverter or EL panel as appropriate.

2. If the EL panel is illuminated and the unit is still not working, proceed to TEST 104 (μP QUICK CHECK).

6-307. TEST 104 (μP QUICK CHECK).

This test determines if a blank display is caused by a control board error or the display circuit.

1. Press ESCAPE and MULTI and set the range on 6. Monitor TP13 of any input module on the scope and put a medium signal into a sensor (or connect the 2500 DC Range Calibrator and set it on range 3). Now set the range to 0; if the signal changed the microprocessor is OK and the display circuits are at fault. Do TEST 105 (DISPLAY CIRCUITS).

2. If there is no change, the microprocessor or other circuits are at fault; do a hard restart with the bit switches and retry; then do TEST 106 (μP DEBUG).

6-308. TEST 105 (DISPLAY CIRCUITS).

Refer to the appropriate paragraph below depending on the display condition.

1. **Display Black.** An inoperative -5 V supply for viewing angle control would cause the LCD to appear black. Measure -5 V at U29 pin 2 (the junction of C25 and R27). Check for variable voltage at pin 2 of J6 connector by rotating potentiometer R27.

2. **Display White (No characters).** A display lit and showing boxes indicates that the display unit has been reset at power up but that it is not getting proper control signals from the μP. If the μP checked out OK (TEST 104), the display unit itself or the interface circuitry is suspect. Check for the following:

a. U15 failure: the display must be selcted by the μP to operate. Check for chip-select activity at U15 pin 11. If there is no CS-, see TEST (106) (μP).

b. U33 failure: a string of inverting buffers is used to impart a delay to the CS-. Check for CS activity at pin 12 of J6.

c. U24 failure: the data bus is buffered from the display. The lack of data transfer will cause boxes on the display. Check CS- activity. Check for data transfer through buffers by comparing input with output pins. Replace the buffers as required.

d. LCD defection: replace the LCD unit.

6-309. TEST 106 (MICROPROCESSOR DEBUG).

Microprocessor (μP). The μP, of all circuits is probably the most difficult to troubleshoot. Many of the signals associated with the μP, such as the data and address signals, are dependent upon asynchronous external stimulation or software routines which vary with application. The μP encompasses circuits including: ROM, RAM, Clock and Timing. Failure of any of which may cause catastrophic failure. Check for the following conditions and refer to the appropriate section.

1. There should be continual activity on AS- (pin 28 of the μP). If not, be sure that HALT- and RESET are high (RESET- is driven by U23; HALT is driven low by either U23 or the μP). Replace the μP as necessary.

3. The signal AS- transition to logic low should be followed by a logic low on the DTACK- input at TP2. A transition to logic low at pin 28 followed by a low transition at TP2 is an indication that the μP is executing memory or I/O instructions. If AS- has activity but DTACK- does not, check for activity on U11 pins 8 and 9. If not, release U11. Also check U8 pins 6 and 8 and replace it if there is no activity. Proceed to TEST 107 (RAM) if the unit is stil not working.

6-310. TEST 107 (NON-VOLATILE RAM).

A RAM circuit failure is indicated by loss of calibration constants or the MEMORY FAIL message, or catastrophic malfunction of the μP. That is, a severe memory failure could lock up the μP so that the memory test itself could not be executed. A MEMORY FAIL display indicates that test data written to the RAM has not been read correctly and that the RAM chip may be at fault. If the 4300 gives a battery error or memory fail on power up, do the following tests:

1. With the instrument power off, check battery voltage. In the event that there is valid data in RAM, disturbing the voltage can corrupt the stored data. The voltage should measure more than 3.0 V at CMOS memory U12 pin 28.

2. With instrument power on, voltage at U12 pin 28 should be 4.8 V ±0.3 V.

6-311. TEST 108 (KEYBOARD CIRCUITS).

NOTE

Press TEST, 1, ENTER to initiate the key test.

If the Boonton message appears on the display on power up and it goes into measurement mode, yet the keyboard is unresponsive, the μP is most likely OK and the problem is in the keyboard circuits.

Integrated circuit U34 scans a matrix of key switches and produces a code used by the μP to identify that key.

1. Check for chip select activity at pin U34 pin 22. If there is no activity, see the appropriate pin on the μP.

2. Check for scanning signals RL0-RL7 and SL0-SL4. Lack of scanning signals indicates either the keyboard chip was not initialized for scanning mode due to μP failure, bad U34, or no clock on U34 pin 3.

3. If U34 is functional, the keyboard can be examined for scanning signals to localize the failure to the cable or sockets.

6-312. TEST 109 (GPIB/IEEE-488 BUS).

GPIB failure is indicated when the instrument's display functions properly but the instrument will not respond to any GPIB command. Integrated circuit U32 is a specialized GPIB controller while U25 and U26 are buffers.

1. Check for μP related activity on U32 pins 3, 4, 5, 9, 18 and 19. If there is no activity, check the μP.

2. Check INT- U32 pin 9 for logic high. The interrupt signal INT- should go locic low whenever the instrument is addressed to talk and listen by an external controller.

3. Check signals on buffer chips U25 and U26 for input vs. output. The signals on the corresponding input/output pairs 2-18, 3-17, etc., should have similar timing. If not, repalce defective U25 or check for data bùs shorts. Check U26 in a similar fashion and replace as required.

6-313. TEST 110 (CHOPPER CLOCKS, PHASE-LOCKED-LOOP [PLL]).

If the μP, keybaord and display appear to be working but the power readings are eratic or locked up, the chopper drive clocks could be at fault.

The clock used by the input channels is geneated in synchronization to the AC power line when the line frequency is 50 or 60 Hz. A signal at line frequency is derived by rectifying AC from the secondary of the power transformer and then converting the rectified voltage to a TTL signal. A PLL, U36 and U35 oscillate at a frequency of 1920 Hz or 1600 Hz which is phase-locked to the line.

1. Check U37 pin 3 for a rectangular pulse with a period of the line frequency; replace U37 or CR8 as required.

2. Pin 4 of U36 should be a square wave at 60 Hz or 50 Hz. Also, pin 7 of U35 should be a square wave at 480 Hz or 400 Hz. If either of these signals is not there and the input (pin 10) is OK, replace U35. If there is still a problem, go to TEST 111 (INTERNAL BUS).

6-314. TEST 111 (INTERNAL BUS).

If the keyboard-initiated memory test and display tests function, but the channels and the 30 MHz calibrator do not operate, the problem may be the internal bus. The bus operates as follows:

1. The bus buffers are enabled only when data is being transferred. U5a and Ub5 produce a chip select which enables U1, U2 and U3. A logic low should appear at pin 19 whenever CSZ80, CSCALMEM, or CSCAL8255 are logic low. Signal CSZ80 is active whenever a channel is accessed by the control. Signals CSCALMEM or CSCAL8255 are active only when the calibrator level is changed.

2. Buffer U1, U2, U3 and U4 can be checked by comparing input to output. Buffer U1 is bi-directional with WR(not) on pin 1 specifying the direction of data travel. A high reads data from the bus assembly (channel) while a low writes data to the bus assembly.

3. Put the instrument in multichannel mode and look for activity on all data and address lines. Pulses that are very short and infrequent are acceptable. Also, each of the 6 chip select lines going out to the channel modules should have activity. If not, the 82C55 (U27) on the control board may be bad. Run the bit switch test; if S1 and S2 can be read, the 82C55 is probably OK; in that case, remove the channel modules and the 30 MHz calibrator for activity again on all lines.

4. If particular lines are OK now, then a channel module could be shorting out a line. Replace the buffer I/C's on the channel as required. If some lines still show no activity, replace the appropriate buffer I/C's (U1, U2, U3, U4) on the control board.

6-315. TEST 112 (CHANNEL SWAPPING).

If some of the channels work but some do not, swap two or more of them. If the problem follows the channel module, the module is defective; see TEST 200.

If the problem is with a slot, the first step is to look for "HOLD CH n" lines (1 of 6) on the appropriate line, coming from the 82C55 (U27) on the control board. Replace U27 on the control board if it is suspected.

6-316. TEST 113 (EMPTY FRAME CHECK).

If the entire instrument is erratic, one of the channels or the 30 MHz calibrator may be corrupting the internal bus. Remove all the modules and do the Memory Test (press TEST, 3, ENTER). If this test runs satisfactorily, install channels and/or the calibrator one at a time until the 4300 fails, and troubleshoot that module. If the 4300 does not operate with all the modules removed, go to TEST 100.

6-317. TEST 200 (CHANNEL TROUBLESHOOTING).

Before attempting repairs, a quick check of the channel RAM contents can be made by resetting the module. This will clear out all the DC calibration constants and all channel parameters such as range, frequency, etc. Resetting will also load appropriate default values into the calibration variables. Therefore, when the module is reset, it will have to be DC calibrated using the 2500 DC Calibrator, or, the calibration data on the shield label can be re-entered.

To restart the channel, power down the 4300 and set the bit switch to:

1 Open
2 Open
3 Open
4 Open

NOTE

The battery error indication may be ignored during testing until the bit switch is returned to its normal position. In general, the bit switch is read on power up and at the end of the continuous tests, so when switching from a non-continuous test the 4300 will have to be powered down, and then up again, twice. When powering up, wait 3 seconds each time.

Power up and wait 3 seconds. A working module will indicate a battery error, indicating that the battery control byte has been reloaded. Power down and set the switches back to their normal operating positions, see Table 6-202. Power up and check the 4300 display for basic working operation. If it appears OK, proceed to TEST 210. If not, do TEST 201.

6-318. TEST 201 (Z80, RAM, ROM TEST).

The digital portions of the channel are checked with this test. Set the bit switch to the RAM test as shown in Table 6-202. This test checks the basic operation of the Z80, every byte in RAM, the PROM, decoder U6 and latch U17. Connect a scope probe to U17 pin 9, and power up. A working module will indicate a logic 1 for 1 second each time the test runs (runs continuously). The test itself takes about ½ second (1½ total). Also, each bit of the latch should toggle at this 1½ second rate, every other bit being complemented (for example, pin 2 starts out 1 and goes to 0 when the test passes). If this test fails, perform TEST 202. If it passes, proceed to TEST 204.

6-319. TEST 202 (Z80).

Check for a 2 MHz clock at pin 6 of the Z80, if not trace back to the control board or look for shorts. Check pins 21 and 22 (read and write lines) of the Z80 for activity. If not, replace the Z80, RAM or U6 IC's as required. (The buffer I/C's U7, U8 and U9 do not get checked during this test, however, a shorted input on one of these could possibly affect TEST 202. If they are suspect, this test can run without these.) Activity should be present on all data and address lines; even very short pulses are OK. If the trouble cannot be found with these checks, remove the Z80 and install test adapter Boonton P/N 042283, and reinstall the Z80. This ties up the data lines and puts the Z80 into continuous "NO-OPS", causing it to run through all addresses.

Look for square waves on all the address lines with the MSB's showing the lowest frequencies. Also, shorting pin 17 (NMI) to ground momentarily should cause pin 18 (HALT) to go low. If it does, the Z80 is running and the PROM is probably OK. If not, look for trouble in the PC board (shorts, etc.). In addition, TEST 203 may be run to further isolate the problem. Once the problem is found, proceed to TEST 204.

6-320. TEST 203 (DECODER TEST).

Set the Bit switch to the decoder test. A working module will show activity on all the outputs of the decoder U6.

6-321. TEST 204 (+5 VDC REFERENCE).

Check for 5.00 VDC ±10 mV at TP 9; if not, remove U20. If voltages does not come up, replace U19 or Q3. Recheck and then continue with TEST 205.

6-322. TEST 205 (RECORDER DAC TEST).

Put the Bit switch in the chart recorder test and power up. The DAC output at the BNC should indicate a double ramp; the first one being 0 to 156 mV, and the second from 0 to 10 V. The period is a few seconds. The ramp should be linear with no discontinuities or steps other than the two re-traces.

If this is not the case, check for -10 VDC at pin 19 of the DAC and track back through AR4 as necessary (TP9 should have +5 VDC on it; see TEST 204).

If these appear OK, check pins 2 and 3 of AR5. If they differ by more than .05 VDC or either one is above ±0.2 VDC, replace AR5. If there is still a problem, replace the DAC. Continue with TEST 206.

6-323. TEST 206 (A/D TEST 1).

Note: As of this writing, this test is inoperative. Proceed to the next test. When complete, this test will be run as follows:

Connect the recorder BNC to TP8, and a 1.78K 1% resistor from TP8 to ground. Set the Bit switch to the A/D Test 1 position and power up. No signal should be present at the sensor input, and the range should be set to 3 or higher. This test walks a "1" through the DAC and A/D and checks for proper rough operation. A working module will indicate a "1" on U17 pin 9 for 1 second every time the test passes (runs continuously). The test takes about 5 seconds.

If the test fails, check fo 1 MHz on pin 8 of the A/D and trace back to the control board if it is not there. Check pin 3 of the A/D; it should be a non-linear staircase from 0 to 4 V. If not, replace AR3 and/or CR4. (Check TP8 for a 0.13 V staircase before doing this and perform TEST 205 if necessary.)

If these all fail, replace the A/D. Recheck and go to TEST 207.

6-324. TEST 207 (A/D TEST 2).

Connect the recorder DAC BNC to TP8 through an 18.2K 1% resistor, and TP8 through an 84.5 Ω 1% resistor to ground, and TP8 to TP4 through a 432 Ω 1% resistor. Set the Bit switch to "2AD TEST", and power up.

Check TP4 for -5 VDC and monitor U17 pin 9. This test slides the A/D through a small portion of its range and checks the resolution. A working module will show a logic 1 on pin 9 for 1 second every time the test passes (runs continuously). The test takes about 15 seconds. If the proper indication does not appear, and TEST 206 passed, check for shorts between data lines on the A/D, and replace the A/D if necessary. Continue with TEST 208.

6-325. TEST 208 (CONTROL BOARD COMMUNICATION).

Up to now in the Input Channel Tests the 4300 mainframe has been used only for power and clocks. Tests previous to this have checked only the input channel. Set the Bit switch on the channel to the RAM test and power up. From the 4300 keyboard, select single channel mode, range 3, and select the raw data mode (SPECIAL, 8, ENTER). The display should indicate the A/D value from the input module, and for this test it should be 5461.

Now press the FILTER key and note the default filter value that the instrument has selected. Escape and set range 0; now when the filter value is recalled, the displayed value should have increased. This test assures with reasonable accuracy that the digital sections of the input module and the basic control board are working. If not, do TEST 209, otherwise, go to TEST 210.

6-326. TEST 209 (BUS CHECK).

If the problem appears to be in the input to control board communication, swap the input module with another one if available, to see if the problem stays with the slot or moves with the module.

If the problem is with the slot, the chip select lines going back to the 82C55 on the control board can be checked. They are the only unique lines per module. That is, if other slots are OK then the data and address lines are OK.

If there is still a problem, look for shorts or opens on the bus board. If the problem follows the module, and other modules work, replace the buffers U7, U8, U9 on the channel one at a time. If more than one module is not working, the problem is probably on the control board. When the bus appears to be working, go to TEST 210.

6-327. TEST 210 (OP AMPS AND RANGING).

This test gives a good overall indication that most sections of the channel are functioning and gives a clue to where the problem lies, if there is one. Zero the instrument and via the keyboard, verify that the channel is in autorange mode (incidentally, resetting the module puts it in autorange). With the Boonton Model 2500 or 2510 DC Range Calibrator connected to the sensor input, monitor TP13 with the scope. There should be square waves at 240 Hz or 200 Hz on each range at amplitudes shown in Table 6-301.

TABLE 6-301. INPUT CHANNEL VOLTAGES

Range	TP1	TP2	TP13
0	6.52 mV p-p	1.077 V p-p	1.01 V p-p
1	65.2	4.30	4.00
2	130	8.60	8.00
3	130	8.60	8.00
4	130	8.60	8.00
5	1.30 V p-p	8.60	8.00
6B	6.48	6.48	6.06

Upranging should be smooth and automatic, and should go from range 0 to 6 or vice versa (to range 3 for the 4312) in 150 milliseconds or less.

If the 2500 is not available, run the test using a sensor and an RF source. While voltage measurements cannot be taken, the ranging operation can be checked. However, the range overlap can be tested (if the source can be

incremented in small steps) and it should be about 0.8 dB. Ranging points are sensor dependent and do not fall on even multiples or 10 dB.

Enough information can be gathered from this test to verify operation without using the 2500 Calibrator.

If the ranging appears to be OK, proceed to the dynamic filter check as shown in TEST 211.

If the module does not operate correctly, refer to the conditions specified below, and then refer to the indicated paragraph/test for diagnosis.

For Condition At TP13:	Perform Test:
No square wave; just noise on bottom ranges:	212
Top ranges OK; 0 and 1 have high signals:	213
+5V to -14V square wave on most ranges:	214
Range 6 OK; some ranges not OK:	221

6-328. TEST 211 (DYNAMIC FILTER CHECK).

Put the channel on range 0 and put the 2500 or 2510 on range 0 (alternatively put a small signal into the sensor). Monitor TP13 on the scope, synchronizing on TP14. There will be a lot of noise present. The signal should be a square wave at 240 Hz at 8V p-p or so (200 Hz on a 50 Hz line). The beginning 1/8 of each half cycle will have more noise than the rest of the waveform, because at the 1/8 point, the capacitors C16 and C17 are switched in. The 3 chopper pots may need adjusting; see the Adjustments Section.

If the waveforms do not appear normal, check pins 9 and 10 of U13 for pulses. See the Input Schematic for waveforms. Replace U11 as necessary. (See TEST 218 for more information.) TP2 should be a noisy square wave (the unfiltered version of TP8).

Pin 11 of U13 should be low except for a 4 millisecond positive pulse when the range is changed. This allows C16 and C17 to charge up rapidly when the range is changed. (The analog switches close for a positive control signal.) If everything is in order, proceed to the DC calibration routine as shown in the Adjustments Section.

6-329. TEST 212 (CHOPPER DRIVE TEST).

Check for chopper drive signals at pins 10 and 11 of U12. There should be square waves at 250 Hz ±5V. If they seem OK, go to TEST 215.

If there is no chopper drive, trace back through Q2 which should have the same waveform on its collector. Replace U12 or Q2 as required. If Q2 has no drive (TTL 240 Hz), look for 1920 Hz and 480 Hz at U18 (TTL levels, square waves, trace back to control board if not there). At a 50 Hz line these frequencies are reduced by 5/6.

Finally, check for regulated ±5V at TP3 and TP4. If less than 5V, remove the chopper and see if the voltage comes up; if it does, the chopper is defective. If the voltages are still low, replace U15 or U16 as appropriate.

These procedures should restore the chopper drive. If the chopper drive now appears OK, re-perform TEST 210 and TEST 211.

6-330. TEST 213 (CHOPPER GROSS ADJUST).

Put the channel on the extender card. Lift a screw on the 4300 chassis and connect a short wire between it and a similar ground screw on the channel, near the chopper. Put the channel on range 0 with no signal input. Monitor TP2 and adjust the two chopper pots for a minimum signal. Now adjust the tilt pot near the chopper. Re-perform TEST 210.

If these adjustments do not fix the problem, and the upper ranges seem OK, then the chopper is probably defective; in that case, go to TEST 220.

6-331. TEST 214 (LATCH).

If the ranging test (210) shows a gross overload on most ranges, reset the module with the bit switch (see Table 6-202). If this fixes it, go to TEST 210.

If there is still a problem, check the latch outputs U17 according to the table listed in the Theory of Operation section on each range.

Finally, check the amplifiers as shown in TEST 215.

6-332. TEST 215 (AMPLIFIER MID-POINT, TP2).

With the channel on range 6, and the 2500 on range 6B, monitor TP2 on the scope. (Alternatively, use a sensor and put in an RF signal near the top of the sensor range.)

The voltage at TP2 should be 240 Hz, 6.48 V p-p centered around 0 V. Also, check other ranges according to voltages listed in Table 6-301. If it is, then the amplifiers are Ok; proceed to TEST 216.

If there is a problem, go to TEST 217.

6-333. TEST 216 (FILTER GROSS CHECK).

With the condition as set up in TEST 215, look for a 2.5 V p-p signal at TP8. If it is not there and TP 2 does have a signal, check for proper waveforms at U13 pins 9 and 10 according to the waveforms on the Input Schematic.

If they are OK, then replace U13 (while U13 is out, it may be good to check to see if the signal comes up; if it does, then U13 is not the problem — look for shorts, etc.).

If the waveforms at pins 9 and 10 are not OK, trace back to U18 and replace U11 as necessary.

Finally, check TP13 for 8 V p-p or so and check the AR3 circuits as required. When operation seems normal, re-perform TEST 210 and TEST 211.

6-334. TEST 217 (TP1-AMPLIFIER DEBUG).

With the condition as noted in TEST 215, monitor TP1. There should be 6.48 V p-p centered around 0 V. If there is the AR6-B or U14 are suspect; do TEST 218, If TP1 is not OK, then do TEST 219, otherwise do TEST 218.

6-335. TEST 218 (AR6-B CIRCUITS).

Before replacing AR6 or U14, a simple test can be performed that should isolate the problem. With the instrument on range 6 and the 2500 on range 6B (or the sensor connected with a power near the top of its range), short pins 8 and 9 of U14. If TP2 now looks normal, replace U14, and if that doesn't fix it check the resistor strings. If TP2 didn't change then replace AR6.

Finally, it may be necessary to check the latch outputs (U17) according to the table listed in the Theory of Operation section of this manual. See also TEST 221 for voltages that should be present at TP1 and TP2.

If this fixed the problem, re-perform TEST 210. If the Dc voltages are normal (0V) but there is no signal, do TEST 220.

6-336. TEST 219 (AR1, 2, 6 CIRCUITS).

Before replacing U10, AR1, AR2, or AR6, a test can be run to isolate the problem. Set the instrument to range 6 with no input applied. Measure the DC voltage on AR1, AR2 and AR6-A outputs.

If AR6 is not 0 V and the other two are, replace AR6. If AR1 or AR2 are not OK, unplug the chopper. If this corrects the voltages, the chopper is at fault; see TEST 220.

If all three voltages are zero, the following AC test will have to be done:

Set the channel to range 6 and set the 2500 to range 6B (or use the sensor at the top of its range and look for approximate voltages). Look at pins 1 and 3 of the chopper. There should be 4.5 V p-p at 240 Hz on each pin. If not, do TEST 220. If 1 and 3 are OK, look at the outputs of AR1 and AR2. They should also have 4.5 V p-p on them. If not, short pins 4 and 8 of U10, and also pins 9 and 13. If this restores the proper AC signal, then U10 is at fault. Othewise, it is AR1 or AR2; these are specially selected devices and must be ordered from the factory, however, stock LF356's may be substituted for checking purposes.

If these things do not remedy the problem check the resistor strings, and finally check the latch outputs (U17) for conformance to the digital signals specified in the table in the Theory of Operations section.

If the proper operation is restored, re-perform TEST 210; if the DC voltages look OK (0 V) but there is no signal, do TEST 220.

6-337. TEST 220 (CHOPPER).

If the chopper is suspected of having a problem, this test may be done. Unplug the chopper leaving the red and black wires attached. Jump pin 8 on the chopper socket to pin 3 through a 100K 5% resistor. Power up and put the channel on range 6. Note where the tilt pot is set to and monitor TP2 on the scope.

When the tilt pot is set to either extreme, TP2 should have roughly 200 mV p-p at 240 Hz on it. In the center of the pot rotation there should be almost 0 V. If these measurements are OK and the input module does not work with the chopper installed, then the chopper is defective. Replace either the chopper I/C (special Boonton P/N, but a stock CD4016 may be used for debugging) or the chopper assembly. When the chopper is working, repeat TEST 210.

6-338. TEST 221 (ANALOG SWITCHES).

If TEST 210 shows a problem only on some ranges, the problem is probably U10 or U14. Check TP1 and TP2 for the voltage in Table 6-301.

If TP1 is OK and TP2 is not, replace U14, otherwise replace U10. Then re-perform TEST 210.

6-339. 30 MHz TROUBLESHOOTING.

The 30 MHz calibrator consists of the 30 MHz Digital Board (located on the extreme right-hand side of the instrument) and the 30 MHz Generator (the shielded assembly). The 30 MHz generator assembly must be removed from the 4300 chassis with the ribbon cable still attched, for troubleshooting. The digital board may be put on the extender card as necessary. The generator assembly should be grounded to the chassis by lifting screws on both units and attaching a wire between them.

The steps below will isolate the trouble to the particular assembly (the Generator assembly or the 30 MHz Digital assembly) and to the portion of circuitry of most probable cause of the fault. Refer to the Troubleshooting Chart at the beginning of the section.

CAUTION

SOME OF THE TESTS OUTLINED BELOW RESULT IN POWER LEVELS AT THE CALIBRATOR OUTPUT OF UP TO 23 dBm; BE SURE THAT THE SENSOR USED HAS AN OVERLOAD RATING ABOVE THIS VALUE.

6-340. TEST 400 (GENERAL BUS OPERATION).

As an assurance that the trouble is in the calibrator and not on the control board, perform the following test. Turn off power and turn it back on. Wait a few seconds for the unit to initialize and go to single channel mode

and select any channel that is installed. The display should indicate a power level, the channel number, the range, etc. With no signal applied to the sensor or with no sensor connected, press SET RANGE 6, ENTER. Verify that the display shows range 6 and HOLD. If it does, proceed to TEST 402. If it does not, do TEST 401.

6-341. TEST 401 (BUS ERRORS).

Bus errors may show up as a "NO CALIBRATOR" message, "MEMORY ERROR" message, or the entire instrument not functioning. To test for shorted bus I/C's, turn off the instrument and remove the 30 MHz Digital board. Power up and retest channel 1 (or any channel) as in test 400 for basic operation. If the channel now works then replace U4 or U5 on the 30 MHz Digital board, and retest. If the channel doesn't work with the 30 MHz Digital board, then refer to the overall 4300 troubleshooting section, TEST 100.

6-342. TEST 402 (RELAY DRIVE).

Press the following keys (Note: the calibrator output will go to 20 dBm; disconnect the sensor from the calibrator if it is not rated for that power). SHIFT, HI LIM, 20, ENTER, CAL LEVEL, 20, ENTER. Check the voltage of the feedthrough capacitors C1, C2, and C3 on the generator assembly for the conditions shown in Table 6-302 under the 20 dBm heading. Logic highs should be above 3 volts and logic lows should be below 0.4 volts. Similarly, check the voltages at other calibrator levels as shown in the table. If any of them are incorrect, trace the signals back to the 30 MHz digital board using the schematics and replace the ribbon cable as required. Also, check the power supplies and ground at the generator and replace the ribbon cable if required. If the voltages are still incorrect, the problem is on the digital board; do TEST 403 and then TEST 404. If the voltages at the feedthrough capacitors appear OK, the digital board is partially OK, but the DAC has to be tested as shown in TEST 403.

TABLE 6-302.
30 MHz CALIBRATOR ATTENUATORS

Level	C3 10 dB	C2 20 dB	C1 40 dB
+20	HI	HI	HI
+10	LO	HI	HI
0	HI	LO	HI
-10	LO	LO	HI
-20	HI	HI	LO
-30	LO	HI	LO
-40	HI	LO	LO
-50	LO	LO	LO
*-60	LO	LO	LO

6-343. TEST 403 (DAC CHECK).

Connect a DC voltmeter to feedthrough capacitor C6 on the generator assembly. Ground the meter at a good point on the casting. Set the calibrator level to 0 dBm and note the voltage reading. Progressively stop the calibrator in 1 dB steps as shown in Table 6-303 and compare the readings to those in the table. The voltages at 0 dBm should be between 5.5 and 7.8 VDC. (If not, perform a calibration of the calibrator as listed in other sections of this manual and try again.) Divide each voltage reading by the reading of 0 dBm. Each additional 1 dB downward step should cause the voltage to decrease by the ratios shown in the table. For example, at -1 dBm, the voltage when divided by the voltage of 0 dBm should be 0.8913. These ratios should be accurate to 0.1%. If there is no voltage at all or if the voltages are incorrect, the digital board is at fault. Go to TEST 404. If everything appears normal, go to TEST 405.

TABLE 6-303. 30 MHz CALIBRATOR CONTROL VOLTAGE

-dBm step	Ideal Voltage Ratio	Typical Voltage At C6
0 dBm	1.000	6.679V
-1 dBm	0.8913	5.590V
-2 dBm	0.7943	5.303V
-3 dBm	0.7079	4.726V
-4 dBm	0.6310	4.213V
-5 dBm	0.5623	3.752V
-6 dBm	0.5012	3.344V
-7 dBm	0.4467	2.980V
-8 dBm	0.3981	2.657V
-9 dBm	0.3548	2.368V

6-344. TEST 404 (30 MHz DIGITAL BOARD).

If TESTS 402 and 403 both failed, and the control board is OK, the problem is on the digital board, and most likely the 8255 on the digital board (U2). Put the digital board on the extender card if desired for testing. Replace U2 and recheck operation. If there is still a problem, replace U4 and U5 in that order. Finally, repalce U3 which is the EEPROM and recalibrate the calibrator. (It is necessary to recalibrate if the EEPROM is replaced to get any output at all since the levels are stored in the software.)

If only TEST 403 failed, check the DC voltages at U6 pins 2 and 3 (op amp); if they are different by more than 10 mV, replace the op amp. If they are the same, replace the D to A converter U1. If this is done, the calibrator will have to be recalibrated. Refer to test 410 once the problem is found.

If TESTS 402 and 403 passed, go to TEST 405.

6-345. TEST 405 (ISOLATION OF GENERATOR SECTIONS).

To determine roughly what area of the generator the problem lies in, perform the following test. With the calibrator terminated in 50 ohms, set the calibrator level to 0 dBm and check the AC voltage at K1 pin 8. If it differs significantly from 6.33 volts peak to peak (by more than 1 volt), the problem is the amplifier or the oscillator. Go to TEST 406. If it appears normal, go to the attenuator test, TEST 409.

6-346. TEST 406 (OSCILLATOR).

Connect a scope probe to TP1 on the generator assembly and set the level to 20 dBm via the front panel. There should be a 30 MHz signal at about 6 V peak to peak. If there is, proceed to TEST407. If not, check for the following conditions: Note: Q1, Q2, and Q4 should operate independently from the rest of the generator. Even if there is trouble elsewhere, there should be oscillation in this circuit.

1. The collector of Q2 should be greater than 14 VDC. If not, check for a low at J46 pin 8. Check for shorts in the DC path on Q2, and hot components. Replace Q2 as necessary.

2. The emitter of Q1 should be 1 VDC ± 0.5 V. Replace Q1 and suspected passive components as required. Replace the crystals as required.

3. The emitter of Q4 should be from 6 to 10 VDC and oscillating at 3.5 to 5.8 V peak to peak. Replace Q4 as required.

Once oscillation has been verified, proceed to TEST 407.

6-347. TEST 407 (AMPLIFIER Q5).

Set the calibrator level to 0 dBm. Check TP2 using the scope. There should be from 16 to 24 peak to peak at 30 MHz. If there is, proceed to TEST 409. If the voltage is low, short the emitter to the collector of Q3 and try again. If this brings the voltage up, the problem is in the control loop; go to TEST 408. If the voltage is still too low, replace Q5. Also, replace suspected passive components that follow Q5 (C14, etc.). With Q3 still shorted, adjust C12 for a maximum level at K1 pin 8. Once the problem is found and repaired, go to TEST 410.

6-348. TEST 408 (CONTROL LOOP).

The control loop consists of U1, CR2, CR3, Q3, and associated components. The circuit compares the DC voltage at the CR2 anode to the AC voltage at the CR3 anode. U1 then applies the proper DC voltage to the Q5 amplifier (through Q3) to maintain the balance. If the oscillator or amplifier are not functioning, the voltage at U1 pin 6 will be high, in an effort to bring up the output. Similarly, if Q3 were shorted, the full DC voltage would be applied to the amplifier and the loop would try to compensate by forcing U1 pin 6 to near ground.

First check the op amp by measuring the DC voltages at pins 2, 3 and 6 of U1. The op amp is suspect if any of the conditions below are present:

1. Pin 2 is higher than Pin 3 by more than 10 mV and pin 6 is greater than 2 VDC, or,

2. Pin 2 is less than pin 3 by more than 10 mV and pin 6 is less than 12 VDC. (It may be necessary to remove Q3 and CR1 for this test if the voltage appears to be shorted to ground.)

Check to see that the DC voltage at pin 2 of the op amp is roughly equal to the peak voltage at the CR3 anode, and that the voltage at pin 3 of the op amp is about 0.5 V lower than that of CR2 anode. If not, replace the diodes as required. Also, replace Q3 as required. Once the control loop has been repaired proceed to TEST 410.

6-349. TEST 409 (ATTENUATOR).

The attenuator consists of 3 sections having switched attenuations of 10, 20, and 40 dB. The resistors are precision, primarily for stability. Errors in resistance values of several percent can be tolerated because errors are compensated for in software. Most attenuator faults will occur with the switch driver transistors and with the relays.

TABLE 6-304.
30 MHz CALIBRATOR RF VOLTAGES

Level in dBm	Output at N Connector Terminated (volts pk-pk)
20 dBm	6.30 V pk-pk
10 dBm	2.00 V pk-pk
0 dBm	630 mV pk-pk
-10 dBm	200 mV pk-pk
-20 dBm	63 mV pk-pk
-30 dBm	20 mV pk-pk
-40 dBm	6.3 mV pk-pk
-50 dBm	2.0 mV pk-pk

Check Q6 through Q8 by setting the calibrator level in 10 dB increments as shown in Table 6-302. When the base drives are low, the transistors should be on and their collectors should be from 3.2 to 4.2 VDC. Otherwise they should be 0 VDC. Replace the transistors as required. The switching of the relays should be audible. If there is relay drive but no "clicking", the relay is probably at fault. If a particular section is suspected, it can be cycled by changing the output level by that amount. For example, changing from 20 dBm to 0 dBm

will cycle the 20 dB pad. Refer to Table 6-302 to see which relays switch for various level changes. Also see Table 6-304 for the RF voltages for various levels. If the relays all "click" and there is still a problem, the contact are probably bad. Replace the relays as required. Finally, replace the precision resistors as required. Proceed to TEST 410.

6-350. TEST 410 (CONCLUSION).

Button up the calibrator and recheck basic operation at various power levels. If repairs have been made to the analog circuits (including the D to A converter), recalibration will be necessary. Refer to the calibration section of this manual. Repairs to the digital circuits or the relay drive circuits will not require recalibration. However replacement of a relay requires recalibration if maximum accuracy is desired since the contact resistance varies somewhat from unit to unit. At the manufacture time of the generator, the relays are cycled about 1000 counts to "wear in" the contacts. If this is desired, return the unit to the factory.

6-351. TEST 300. 50 MHz CALIBRATOR TROUBLESHOOTING.

With the 50 MHz calibrator removed from the 4300 but still connected, perform the following tests:

Terminate the output with 50 ohms and connect a scope probe between the junction of C10 and R15. The amplitude should be 1.2 V p-p, +/- 0.4 V. The frequency should be 50 MHz +/- 0.5 MHz. If the voltage is too high, the control loop is probably not working; AR1 is probably at fault. If there is no signal, check the emitter voltage of Q1; it should be -11 V +/- 2 V. If it is not within those limits, Q1 may be shorted or open.

A low signal at the C10 R15 junction may be due to a misadjustment of C4 or C12. Also, the reference voltage should be checked at U1 pin 1, for 10.0 V. If this is too low or too high, U1 is at fault.

Pin 3 of AR1 should be -3 to -4 V; if not check the reference voltage path. Pin 2 of the same op amp should be equal to pin 3 within 5 mV; if not, check R6, R9, CR3, and CR2 for opens or shorts.

SECTION 7
PARTS LIST

7-1. INTRODUCTION

Table 7-2. Replaceable Parts, lists all the replaceable parts and includes: the reference symbol, description, Mfr., Mfr's Part No. and the BEC Part No. Table 7-1. Manufacturer's Federal Supply Code Numbers, list the manufacturer's federal supply numbers.

TABLE 7-1. MANUFACTURER'S FEDERAL SUPPLY CODE NUMBERS

Number	Name	Number	Name
00241	Fenwal Electronics	31313	Components Corp.
01121	Allen Bradley	31918	ITT Schadow, Inc.
01247	Sprague Electric Company	32575	AMP
01295	Texas Instruments	32897	Erie
02660	Amphenol	32997	Bourns, Inc., Trimpot Div.
02735	RCA Solid State Division	33297	NEC
03888	Pyrofilm (KDI)	33883	RMC
04713	Motorola Semiconductor	34335	Advanced Micro Devices
04901	Boonton Electronics	51640	Analog Devices, Inc.
06383	Panduit Corp.	52464	OKI
06776	Robinson Nugent, Inc.	54420	Dage — MTI
07263	Fairchild Semiconductor	54426	Buss Fuses
07326	Fairchild Semiconductor	54473	Panasonic
13812	Dialco Div. of Amperex	56289	Sprague Electric Company
14655	Cornell-Dubilier	56708	Zilog, Inc.
17801	Panel Corp. (Schurter)	57582	Kahgan Electronics Corp.
19701	Mepco Electra	61637	Kemet-Union Carbide
20307	Arco — Micronics	71450	CTS Corp.
24226	Gowanda Electronics	73138	Beckman Instr., Helipot Div.
27014	National Semiconductor	81073	Grayhill
27264	Molex, Inc.	91293	Johanson
27735	F-Dyne Electronics	91506	Augat
27777	Varo Semiconductor	98291	Sealectro Corp.
28480	Hewlett-Packard Corp.	99942	Centralab
		S4217	United Chemicon, Inc.

TABLE 7-2. REPLACEABLE PARTS

04310101A FRAME ASSY (4300)
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A4	SIDE FRAME LEFT ASSY	04901	04311200A	1	04311200A
A7	PWA CONTROL 4300	04901	04310300F	1	04310300F
A11	PWA BUS 4300	04901	04310700A	1	04310700A
A13	PANEL SUB ASSY	04901	04311600B	1	04311600B
U6	PROM 4300 A7 U6 CONTROL	04901	53441500D	1	53441500D
U18	PROM 4300 A7 U18 CONTROL	04901	53439900D	1	53439900D

04311200A SIDE FRAME LEFT ASSY
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
T1	TRANSFORMER POWER	04901	44609600A	1	44609600A
W28	CABLE ASSY	04901	57121702A	1	57121702A
W37-38	CABLE ASSY	04901	57121802A	2	57121802A
W48	CABLE ASSY (TRANSFORMER)	04901	57122900A	1	57122900A

04310300F PWA CONTROL 4300
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
BT1	CELL LITHIUM 3V	54473	BR2325-1HB	1	556007000
C1-2	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	2	224268000
C4-6	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	3	224268000
C7	CAP TANT 15uF 10% 20V	56289	196D156X9020KA1	1	283227000
C8-12	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	5	224268000
C13	CAP EL 10uF 20% 25V	S4217	SM-25-VB-10-M	1	283336000
C14	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C15-16	CAP EL 4700uF -10%+50% 16V	S4217	SM-25-VB--100-M	2	283352000
C17-18	CAP EL 2200uF -10%+50% 35V	57582	KSMM-2200-35	2	283351000
C19-21	CAP EL 100uF 20% 25V	S4217	SM-25-VB-100-M	3	283334000
C22-23	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	2	224268000
C24-25	CAP EL 10uF 20% 25V	S4217	SM-25-VB-10-M	2	283336000
C26-27	CAP CER 0 1uF 20% 50V	04222	SR215E104MAA	2	224268000
C28	CAP MPC 0.01uF 2% 50V	14752	652A-1A-103G	1	234142000
C29	CAP MPC 0.1uF 2% 50V	14752	652A-1-A-104G	1	234139000
C30-34	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	5	224268000
CR1	DIODE SIG 1N914	01295	1N914	1	530058000
CR2	DIODE SIG 1N4001	04713	1N4001	1	530151000
CR3	DIODE SIG 1N914	01295	1N914	1	530058000
CR4	DIODE ZENER 1N5231B 5 1V 5%	04713	1N5231BSZ	1	530169000
CR5	DIODE BRIDGE KBP-02	15281	KBP02	1	532013000
CR6-7	DIODE SIG 1N4001	04713	1N4001	2	530151000
CR8	DIODE SIG 1N914	01295	1N914	1	530058000
CR9	DIODE ZENER 1N5231B 5.1V 5%	04713	1N5231BSZ	1	530169000
J28	HEADER 3 PIN STRAIGHT .156 SPA	06383	HPSS156-3-C	1	477343000
J29	CONN M 02 CIR .1 SP PLZ STRAIT	06383	MPSS100-2-A	1	47740702A
J30	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
J31	CONN M 02 CIR .1 SP PLZ STRAIT	06383	MPSS100-2-A	1	47740702A
J32	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
J34	SOCKET IC 24 PIN	06776	ICN-246-S4-G	1	473043000
J35	HEADER 9 PIN STRAIGHT .1 SPACE	06383	HPSS100-9-C	1	477374000
J36	HEADER 5 PIN STRAIGHT .1 SPACE	06383	HPSS100-5-C	1	477382000
P27	CONNECTOR DIN 64 CKT FEMALE	06776	RNE-64CRS-SR-TG30	1	479434000
Q1	TRANS NPN 2N3904	04713	2N3904	1	528071000

TABLE 7-2. REPLACEABLE PARTS (Cont.)

04310300F PWA CONTROL 4300
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
R1-4	RES NETWORK 3K/6.2K 2% 2.7W	73138	785-5-R3K/6.2K	4	345031000
R5	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R6	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	1	341365000
R7	RES MF 147K 1% 1/4W	19701	5043ED147K0F	1	341516000
R8	RES MF 3.01K 1% 1/4W	19701	5043ED3K010F	1	341346000
R9	RES VAR 1K 10% 0.5W	73138	72PR1K	1	311316000
R10	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R11	RES MF 47.5K 1% 1/4W	19701	5043ED47K50F	1	341465000
R12	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R13	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	1	341365000
R14	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R15	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	1	341329000
R16	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R17	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R18	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R19-20	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	2	341365000
R21	RES MF 2.00K 1% 1/4W	19701	5043ED2K000F	1	341329000
R22	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R23	RES MF 4.99K 1% 1/4W	19701	5043ED4K990F	1	341367000
R24	RES MF 2.21K 1% 1/4W	19701	5043ED2K210F	1	341333000
R25	RES MF 12.7K 1% 1/4W	19701	5043ED12K70F	1	341410000
R26	RES NETWORK 10K 2% 1.5W SIP	71450	750-101-R10K	1	345038000
R28	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	1	341365000
R29	RES NETWORK 100K 2% 1.5W	71450	750-61-R100K	1	345032000
R30	RES NETWORK 3K/6.2K 2% 2.7W	73138	785-5-R3K/6.2K	1	345031000
R31	RES MF 39.2K 1% 1/4W	19701	5043ED39K20F	1	341457000
R32	RES MF 147K 1% 1/4W	19701	5043ED147K0F	1	341516000
R33	RES COMP 10M 5% 1/4W	01121	CB1065	1	343700000
R34	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R35	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R36	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R37	RES MF 1.00M 1% 1/4W	14674	5043ED1M000F	1	341600000
R38-40	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	3	341365000
S1	SWITCH ROCKER 8PST DIP	81073	76SB08	1	465225000
S2	SWITCH SLIDE SPST (4 SW)	71450	206-4ST	1	465219000
U1	IC 74LS645 TRANSCEIVER	01295	SN74LS645N	1	534382000
U2-4	IC 74LS541 OCTAL BUFFER	01295	SN74LS541N	3	534381000
U5	IC 74LS08 QUAD 2 INPUT AND	18324	SN74LS08N	1	534156000
U7	IC 74LS138 DECDR/MPX	01295	SN74LS138N	1	534246000
U8	IC 74LS74 FLIP FLOP	01295	SN74LS74N	1	534157000
U10	IC 5564 8Kx8 RAM CMOS 28 DIP	TOSHIB	TC5564PL-15	1	534403000
U11	IC 74LS93 DIVIDE BY 16 COUNTER	01295	SN74LS93N	1	534230000
U12	IC 5564 8Kx8 RAM CMOS 28 DIP	TOSHIB	TC5564PL-15	1	534403000
U13	IC 74LS02 2 INPT POS NOR	01295	SN74LS02N	1	534154000
U14	IC 74LS08 QUAD 2 INPUT AND	18324	SN74LS08N	1	534156000
U15	IC 74LS32 QUAD 2 INPUT OR	01295	SN74LS32N	1	534168000
U16	IC 74LS04 HEX INVERTER	01295	SN74LS04N	1	534155000
U17	IC 74HC00 QUAD 2 INPUT NAND	01295	SN74HC00N	1	53442505A
U19	IC 68008 MICROPROCESSOR 16 BIT	04713	MC68008L10	1	534402000
U20	IC 74LS93 DIVIDE BY 16 COUNTER	01295	SN74LS93N	1	534230000
U22	IC 339 QUAD COMPARATOR	27014	LM339N	1	535018000
U23	IC 7407 HEX BUFFER	01295	SN7407N	1	534066000
U24	IC 74LS645 TRANSCEIVER	01295	SN74LS645N	1	534382000
U25	IC 75160 IEEE BUS TRANSCEIVER	01295	SN75160BN	1	534286000
U26	IC 75161 IEEE BUS TRANSCEIVER	01295	SN75161BN	1	534287000
U27	IC 82C55 INTERFACE	34371	CP82C55A	1	53441100A
U29	IC 79L05 VOLT REG	04713	MC79L05ACP	1	535090000
U30	IC 74LS138 DECDR/MPX	01295	SN74LS138N	1	534246000
U32	IC 9914ANL IEEE BUS PROCESSOR	01295	TMS9914ANL	1	534288000
U33	IC 74LS04 HEX INVERTER	01295	SN74LS04N	1	534155000
U34	IC 8279-2 KEYBD/DISP INTERFACE	33297	uPD8279C-2	1	534211000
U35	IC 4040B COUNTER/DIVIDER	02735	CD4040BE	1	534275000
U36	IC 4046B PHASE LOCK LOOP	02735	CD4046BE	1	53444706A
U37	IC 4093B QUAD 2 INPUT NAND	02735	CD4093BE	1	53444714A
W39	CABLE ASSY 2 COND 2 SPADE LUG	04901	571206000	1	571206000
XS1	SOCKET IC 16 PIN ANGLED PC MT	51167	16-810-90T	1	473075010
XS2	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000
XU1-4	SOCKET IC 20 PIN	06776	ICN-203-S3-G	4	473065000

TABLE 7-2. REPLACEABLE PARTS (Cont.)

04310300F PWA CONTROL 4300
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
XU5	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU6	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000
XU7	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XU8	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU10	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000
XU11	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU12	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000
XU13-17	SOCKET IC 14 PIN	06776	ICN-143-S3-G	5	473019000
XU18	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000
XU19	SOCKET IC 48 PIN	06776	ICN-486-S5-G	1	473076000
XU20	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU22-23	SOCKET IC 14 PIN	06776	ICN-143-S3-G	2	473019000
XU24-26	SOCKET IC 20 PIN	06776	ICN-203-S3-G	3	473065000
XU27	SOCKET IC 40 PIN	06776	ICN-406-S4-TG	1	473052000
XU30	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XU32	SOCKET IC 40 PIN	06776	ICN-406-S4-TG	1	473052000
XU33	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU34	SOCKET IC 40 PIN	06776	ICN-406-S4-TG	1	473052000
XU35-36	SOCKET IC 16 PIN	06776	ICN-163-S3-G	2	473042000
XU37	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
Y1	OSC CRYSTAL 16 MHz TTL DIP	KYOCER	KXO-01-16.0 MHz	1	547905010

04310700A PWA BUS 4300
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
J19-25	CONNECTOR 44 PIN	31781	305-044-521-202	7	479254000
J26	CONN M 02 CIR .1 SP PLZ STRAIT	06383	MPSS100-2-A	1	47740702A
J27	CONNECTOR 64 PIN RT ANGLE	06776	RNE-64CP-SR-TG30	1	477406000
J28	CONN M 02 CIR .1 SP PLZ STRAIT	06383	MPSS100-2-A	1	47740702A
R1	RES NETWORK 3K/6.2K 2% 2.7W	73138	785-5-R3K/6.2K	1	345031000

04311600B PANEL SUB ASSY
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A5	POWER SWITCH FINAL ASSY	04901	04311701A	1	04311701A
A6	DISPLAY ASSEMBLY LCD	04901	04312100B	1	04312100B
A9	INVERTER ASSY (EL)	04901	04313300A	1	04313300A
A10	PWA KEYBOARD	04901	04310800B	1	04310800B
R1-12	RES MF 120 OHM 5% 1/8W	54473	ERD10TJ-121	12	335654000
W30	CABLE FLAT ASSY 1	04901	57222800B	1	57222800B
W32	CABLE ASSY FLAT	04901	57222707A	1	57222707A

TABLE 7-2. REPLACEABLE PARTS (Cont.)

3111701A POWER SWITCH FINAL ASSY
DEL: 4300

EFERENCE SIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
1	LED YELLOW DIFF 5082-4684	28480	HLMP-1401	1	536034000
	RES MF 267 OHM 1% 1/4W	19701	5043ED267R0F	1	341241000
	SWITCH ROCKER DPDT	13812	572-2121-0103-010	1	465286000
9	CABLE ASSY 2 CONDUCTOR	04901	57222901A	1	57222901A

3113300A INVERTER ASSY (EL)
DEL: 4300

FERENCE SIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
1	CABLE ASSEMBLY 2 CONNECTOR	04901	57222903A	1	57222903A

3108008 PWA KEYBOARD
DEL: 4300

FERENCE SIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
3	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
	RES VAR 25K 10% 0.5W	73138	72PR25K	1	311400000
-30	SWITCH PUSHBUTTON SPST	31918	210272	30	465230000

3114008 REAR PANEL ASSEMBLY
DEL: 4300

FERENCE SIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
	REAR PANEL UNIT	04901	60471600B	1	60471600B
	HEAT SINK ASSY	04901	04311300A	1	04311300A
	FUSE 0.75 AMP 250V MDL SLO BLO	54426	MDL-3/4	1	545533000
4	CABLE ASSY FLAT (GPIB)	04901	57223001A	1	57223001A

4716008 REAR PANEL UNIT
DEL: 4300

FERENCE SIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
	CONNECTOR LINE CORD	82389	EAC309	1	477281000
	SWITCH DUAL SLIDE DPDT-DPDT	82389	47206LFR	1	465279000

TABLE 7-2. REPLACEABLE PARTS (Cont.)

04311300A HEAT SINK ASSY
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1-3	CAP TANT 10uF 10% 35V	56289	196D106X903PE4	3	283353000
CR1	DIODE BRIDGE SDA-980-1	11961	SDA-980-1	1	532030000
U1	IC 323K REGULATOR	27014	LM323K	1	535024000
U2	IC 79MGUIC VOLT REG NEG	07263	uA79MGUIC	1	535043000
U3	IC 78GUIC VOLT REG	07263	uA78GUIC	1	535055000
W35	CABLE ASSY 9 COND	04901	571213000	1	571213000
W36	CABLE ASSY 4 COND	04901	57122400A	1	57122400A

04311900B PLATE CONNECTOR ASSY
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1-12	CAP PP 0.01uF 10% 100V	27735	PP11-.01-100-10	12	23417100A
J1-6	(G) CONNECTOR ASSY FEMALE	04901	09214101C	6	09214101C

04312600A PWA EXTENDER 4300
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
J52	CONN CARD EDGE EXT BRD 44 CRT	31781	307-044-535-202	1	47946544A

TABLE 7-2. REPLACEABLE PARTS (Cont.)

043110018 INPUT ASSY (UNIVERSAL) 4311
MODEL: 4311

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A1	CHOPPER #2 ASSEMBLY	04901	04312202A	1	04312202A
A2	PWA INPUT COMMON 4300	04901	04310400D	1	04310400D
A3	BRACKET INPUT ASSY	04901	043111000	1	043111000
AR1	(G) IC 356B OP AMP SELECTED	04901	535062000	1	535062000
AR2	(G) IC 356B OP AMP SELECTED	04901	535062000	1	535062000
U1	PROM 4300 A7 U1 INPUT	04901	53440700C	1	53440700C
W7	CABLE ASSY (SHIELDED)	04901	57121500A	1	57121500A

04312202A CHOPPER #2 ASSEMBLY
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A1	PWA CHOPPER #2	04901	04310602A	1	04310602A

04310602A PWA CHOPPER #2
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1-2	CAP PP 0.01uF 10% 100V	27735	PP11-.01-100-10	2	23417100A
C3	CAP MICA 8.0pF 10% 300V	57582	KD5080D301	1	205001000
J50-51	CONNECTOR PIN	71279	460-1521-02-03-00	2	477400000
P48	TERMINAL .040 OD .270 LG .062M	98291	229-1071-230	1	510038000
R1-2	RES VAR 25K 10% 0.5W	73138	72PR25K	2	311400000
R3-4	RES MF 51.1K 1% 1/4W	19701	5043ED51K10F	2	341468000
U1	(G) IC SELECTED QUAD SWITCH	04901	534223000	1	534223000
XU1	SOCKET IC 14 PIN	91506	714AG1D	1	473056000

04310400D PWA INPUT COMMON 4300
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
AR3-5	IC 356P OP AMP	04713	LF356N	3	535040000
AR6	IC TL072BCP DUAL OP AMP	01295	TL072BCP	1	535102000
BT1	CELL LITHIUM 3V	54473	BR2325-1HB	1	556007000
C1	CAP TANT 15uF 10% 20V	56289	196D156X9020KA1	1	283227000
C2-7	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	6	224268000
C8-9	CAP MICA 150pF 5% 100V	57582	KD5151J101	2	205009000
C10-11	CAP EL 100uF 20% 25V	S4217	SM-25-VB-100-M	2	283334000
C12-15	CAP EL 10uF 20% 25V	S4217	SM-25-VB-10-M	4	283336000
C16-17	CAP MPC 0.1uF 2% 50V	14752	652A-1-A-104G	2	234139000
C18	CAP MICA 430pF 1% 500V	14655	CD15FD431F03	1	200037000
C19	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C20	CAP CER 0.01uF 10% 100V	04222	SR201C103KAA	1	224269000
C21	CAP EL 10uF 20% 25V	S4217	SM-25-VB-10-M	1	283336000
C22	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C23	CAP EL 1.0uF 20% 35V	56289	196D105X0035HA1	1	283199000
C24-26	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	3	224268000

TABLE 7-2. REPLACEABLE PARTS (Cont.)

04310400D
MODEL: 4300

PWA INPUT COMMON 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
CR1-2	DIODE SIG 1N914	01295	1N914	2	530058000
CR3	DIODE HSCH1001 (1N6263)	28480	HSCH-1001	1	530174000
CR4-6	DIODE SIG 1N914	01295	1N914	3	530058000
J49	CONNECTOR 2 PIN STRAIGHT	27264	22-03-2021	1	477361000
J48/1-48/8	SOCKET SPRING COMPONENT LEAD	32575	1-332070-7	8	479333000
P49	SHUNT 2 CIRCUIT	27264	15-38-1024	1	483253000
Q1	TRANS NPN 2N3904	04713	2N3904	1	528071000
Q2	TRANS PNP 2N3906	04713	2N3906	1	528076000
Q3	TRANS NPN 2N3904	04713	2N3904	1	528071000
R1	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R2	RES NETWORK 100K 2% 1.5W	71450	750-61-R100K	1	345032000
R3	RES MF 5.11K 1% 1/4W	19701	5043ED5K110F	1	341368000
R4	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R5-6	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	2	341365000
R7	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R8-9	RES COMP 12M 5% 1/4W	01121	CB1265	2	343708000
R10	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R11	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R12	RES MF 887 OHM 1% 1/4W	19701	5043ED887R0F	1	341291000
R13	RES MF 442 OHM 1% 1/4W	19701	5043ED442R0F	1	341262000
R14	RES MF 887 OHM 1% 1/4W	19701	5043ED887R0F	1	341291000
R15	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R16	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R17-18	RES MF 8.25K 1% 1/4W	19701	5043ED8K250F	2	341388000
R19-20	RES MF 6.19K 1% 1/4W	19701	5043ED6K190F	2	341376000
R21	RES MF 3.32K 1% 1/4W	19701	5043ED3K320F	1	341350000
R22	RES MF 5.62K 1% 1/4W	19701	5043ED5K620F	1	341372000
R23-24	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	2	341400000
R25	RES MF 1.13M 1% 1/4W	19701	RN55D-1134-F	1	341605000
R26	RES MF 182K 1% 1/4W	19701	5043ED182K0F	1	341525000
R27	RES MF 12.1K 1% 1/4W	19701	5043ED12K10F	1	341408000
R28	RES MF 8.06K 1% 1/4W	19701	5043ED8K060F	1	341387000
R29	RES MF 5.62K 1% 1/4W	19701	5043ED5K620F	1	341372000
R30	RES MF 2.49K 1% 1/4W	19701	5043ED2K490F	1	341338000
R31-32	RES MF 100K 1% 1/4W	19701	5043ED100K0F	2	341500000
R33	RES MF 14.0K 1% 1/4W	19701	5043ED14K00F	1	341414000
R34	RES MF 28.7K 1% 1/4W	19701	5043ED28K70F	1	341444000
R35	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R36	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R37	RES MF 9.09K 1% 1/4W	19701	5043ED9K090F	1	341392000
R38	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	1	341365000
R39	RES MF 150 OHM 1% 1/4W	19701	5043ED150R0F	1	341217000
R40	RES MF 20.0K 1% 1/4W	19701	5043ED20K00F	1	341429000
R41	RES MF 47.5K 1% 1/4W	19701	5043ED47K50F	1	341465000
R42-43	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	2	341200000
R44	RES COMP 1.2M 5% 1/4W	01121	CB1255	1	343608000
R45	RES MF 402K 1% 1/4W	19701	5043ED402K0F	1	341558000
R46	RES VAR 25K 10% 0.5W	73138	72XWR25K	1	311385000
R47	RES MF 402K 1% 1/4W	19701	5043ED402K0F	1	341558000
R48-49	RES MF 28.7K 1% 1/4W	19701	5043ED28K70F	2	341444000
R50	RES MF 4.75K 1% 1/4W	19701	5043ED4K750F	1	341365000
S1	SWITCH 4PST DIP PIANO TYPE	81073	76PSB-04	1	465220000
U2	IC Z80C CPU CMOS	TOSHIB	TMPZ84C00AP	1	53440900A
U3	IC 5564 8Kx8 RAM CMOS 28 DIP	TOSHIB	TC5564PL-15	1	534403000
U4	IC 74HCT541 OCTAL BUFFER	01295	74HCT541N	1	534383000
U5	IC 74HC00 QUAD 2 INPUT NAND	01295	SN74HC00N	1	53442505A
U6	IC 74HCT139 DUAL DEMUX	02735	CD74HCT139E	1	53444208A
U7	IC 74LS645 TRANSCEIVER	01295	SN74LS645N	1	534382000
U8-9	IC 74HCT541 OCTAL BUFFER	01295	74HCT541N	2	534383000
U10	IC 6208 4 CHAN DIF MULTPXR	32293	IH6208CPE	1	534266000
U11	IC 4001B QUAD 2 INPUT NOR	02735	CD4001BE	1	53444721A
U12	IC 4030B QUAD EXCLUSIVE OR	02735	CD4030BE	1	53444722A
U13	IC 4053B TRPL DECDR/DEMULTPXR	04713	MC14053BCP	1	534902000
U14	IC 6108 CMOS CHAN MULTPXR	32293	IH6108CPE	1	534265000
U15	IC 78L05 VOLT REG	07263	uA78L05AWC	1	535044000
U16	IC 79L05 VOLT REG	04713	MC79L05ACP	1	535090000
U17	IC 74HCT373 OCTAL LATCH	01295	SN74HCT373N	1	53444209A
U18	IC 4013B DUAL FLIP FLOP	02735	CD4013BE	1	534205000

TABLE 7-2. REPLACEABLE PARTS (Cont.)

043104000 PWA INPUT COMMON 4300
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
U19	IC AD584JHV VOLTAGE REGULATOR	51640	AD584JH	1	535123000
U20	IC 1205 12 BIT ADC 24 PIN DIP	27014	ADC12058CJ-1	1	53442001A
U21	IC AD7548 12 BIT DAC CMOS	51640	AD7548	1	53512000A
XAR1-6	SOCKET IC 8 PIN	06776	ICN-083-S3-G	6	473041000
XU1	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000
XU2	SOCKET IC 40 PIN	06776	ICN-406-S4-TG	1	473052000
XU3	SOCKET IC 28 PIN	06776	ICN-286-S4-TG	1	473044000
XU4	SOCKET IC 20 PIN	06776	ICN-203-S3-G	1	473065000
XU5	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU6	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XU7-9	SOCKET IC 20 PIN	06776	ICN-203-S3-G	3	473065000
XU10	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
XU11-12	SOCKET IC 14 PIN	06776	ICN-143-S3-G	2	473019000
XU13-14	SOCKET IC 16 PIN	06776	ICN-163-S3-G	2	473042000
XU17	SOCKET IC 20 PIN	06776	ICN-203-S3-G	1	473065000
XU18	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU19	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000
XU20	SOCKET IC 24 PIN	06776	ICN-246-S4-G	1	473043000
XU21	SOCKET IC 20 PIN	06776	ICN-203-S3-G	1	473065000

043111000 BRACKET INPUT ASSY
MODEL: 4311,12,13

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
J9	(G) CONNECTOR ASSY FEMALE	04901	09214101C	1	09214101C
J10	CONN COAX BNC	54420	UG-625/U	1	479123000

TABLE 7-2. REPLACEABLE PARTS (Cont.)

04311003A
MODEL: 4312

INPUT ASS'Y (THERMAL) 4312

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A1	CHOPPER #2 ASSEMBLY	04901	04312202A	1	04312202A
A2	PWA INPUT COMMON 4300	04901	04310400D	1	04310400D
A3	BRACKET INPUT ASSY	04901	043111000	1	043111000
AR1-2	IC OP-27 OP AMP	06665	OP-27-GZ	2	535115000
U1	PROM 4300 A7 U1 INPUT	04901	53440700C	1	53440700C
W7	CABLE ASSY (SHIELDED)	04901	57121500A	1	57121500A

04312202A
MODEL: 4300

CHOPPER #2 ASSEMBLY

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A1	PWA CHOPPER #2	04901	04310602A	1	04310602A

04310602A
MODEL: 4300

PWA CHOPPER #2

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1-2	CAP PP 0.01uF 10% 100V	27735	PP11-.01-100-10	2	23417100A
C3	CAP MICA 8.0pF 10% 300V	57582	KD5080D301	1	205001000
J50-51	CONNECTOR PIN	71279	460-1521-02-03-00	2	477400000
P48	TERMINAL .040 OD .270 LG .062M	98291	229-1071-230	1	510038000
R1-2	RES VAR 25K 10% 0.5W	73138	72PR25K	2	311400000
R3-4	RES MF 51.1K 1% 1/4W	19701	5043ED51K10F	2	341468000
U1	(G) IC SELECTED QUAD SWITCH	04901	534223000	1	534223000
XU1	SOCKET IC 14 PIN	91506	714AG1D	1	473056000

TABLE 7-2. REPLACEABLE PARTS (Cont.)

04313400A 30 MHZ CAL ASSY (FR/REAR OUT)
MODEL: 4321

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A3	30 MHz GENERATOR	04901	04313000A	1	04313000A
A4	PWA 30 MHZ DIGITAL	04901	04312900B	1	04312900B
W4	CABLE ASSY	04901	57222702A	1	57222702A

04313000A 30 MHz GENERATOR
MODEL: 4300

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A1	PWA 30 MHz OSCILLATOR	04901	04312700E	1	04312700E
A2	PWA INTERFACE 30 MHZ	04901	04312800A	1	04312800A
C1-8	CAP FT 3000pF 100V	32575	859617-1	8	227123000
C9	CAP MICA 22pF 5% 300V	14655	CD5CC220J	1	205036000
J43	CONNECTOR TYPE "N"	24253	4889	1	47945500A
L1	INDUCTOR 0.05 uF	04901	40044700A	1	40044700A
W46	CABLE ASSY	04901	57122300A	1	57122300A

04312900B PWA 30 MHZ DIGITAL
MODEL: 4321/4322

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1-5	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	5	224268000
J44	SOCKET IC 16 PIN	06776	ICN-163-S3-G	1	473042000
Q1	TRANS NPN 2N3904	04713	2N3904	1	528071000
R1	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R2	RES MF 681 OHM 1% 1/4W	19701	5043ED681R0F	1	341280000
R7-8	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	2	341400000
U1	IC 565 D/A CONVERTER 12 BIT	51640	AD565AJD	1	421034000
U2	IC 82C55 INTERFACE	34371	CP82C55A	1	53441100A
U3	IC 2804A EEPROM MOS 24DIP	60395	X2804AP-45	1	534401000
U4	IC 74LS645 TRANSCEIVER	01295	SN74LS645N	1	534382000
U5	IC 74LS08 QUAD 2 INPUT AND	18324	SN74LS08N	1	534156000
U6	IC 356P OP AMP	04713	LF356N	1	535040000
XU1	SOCKET IC 24 PIN	06776	ICN-246-S4-G	1	473043000
XU2	SOCKET IC 40 PIN	06776	ICN-406-S4-TG	1	473052000
XU3	SOCKET IC 24 PIN	06776	ICN-246-S4-G	1	473043000
XU4	SOCKET IC 20 PIN	06776	ICN-203-S3-G	1	473065000
XU5	SOCKET IC 14 PIN	06776	ICN-143-S3-G	1	473019000
XU6	SOCKET IC 8 PIN	06776	ICN-083-S3-G	1	473041000

TABLE 7-2. REPLACEABLE PARTS (Cont.)

04312700E PWA 30 MHz OSCILLATOR
MODEL: 4321/4322

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
C1	CAP EL 10uF 20% 25V	S4217	SM-25-VB-10-M	1	283336000
C2-4	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	3	224268000
C5	CAP MICA 120pF 5% 100V	14655	CD5FC121J	1	205022000
C6-9	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	4	224268000
C10	CAP CER 0.01uF 10% 100V	04222	SR201C103KAA	1	224269000
C11	CAP MICA 10pF 5% 300V	14655	CD5WCC100J	1	205002000
C12	CAP VAR 6-55pF 250V GRN	91293	9305	1	281009000
C13	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C14	CAP MICA 30pF 5% 300V	14655	CD5EC300J	1	205019000
C15	CAP MICA 390pF 5% 50V	14655	CD5FY391J	1	205028000
C16	CAP MICA 20pF 5% 300V	14655	CD5CC200J	1	205017000
C17	CAP MICA 51pF 5% 300V	57582	KD5510J301	1	205020000
C18	CAP MICA 10pF 5% 300V	14655	CD5WCC100J	1	205002000
C19	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
C20	CAP MICA 120pF 5% 100V	14655	CD5FC121J	1	205022000
C21-24	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	4	224268000
C25	CAP MICA 2.0pF +-0.5pF 300V	57582	KD05020D301	1	205054000
C26-27	CAP CER 0.001uF 10% 100V	04222	SR151C102KAA	2	224270000
C28	CAP CER 0.1uF 20% 50V	04222	SR215E104MAA	1	224268000
CR1	DIODE SIG 1N914	01295	1N914	1	530058000
CR2-3	DIODE SIG 5082-2800	28480	5082-2800	2	530122000
CR4-6	DIODE SIG 1N914	01295	1N914	3	530058000
CR7	DIODE ZENER 1N5230B 4.7V 5%	04713	1N5230B	1	530103000
CR8	DIODE SIG 1N914	01295	1N914	1	530058000
J46	CONN M 09 CKT SP PLZ .1CT	06383	MPAS100-9-A	1	47740909A
K1-3	RELAY DPDT 5V TO -5 CASE	11532	712-5	3	47105400A
L1	INDUCTOR 5.6uH 10%	24226	15/561	1	400308000
L2	INDUCTOR 0.27uH 10%	24226	10/270	1	400250000
L3	INDUCTOR 15uH 10%	24226	10M152K	1	400373000
L4	INDUCTOR 5.6uH 10%	24226	15/561	1	400308000
L5-6	INDUCTOR 2.2uH 10%	24226	10/221	2	400389000
L7-8	INDUCTOR 0.47uH 10%	24226	10/470	2	400368000
L9	INDUCTOR 0.27uH 10%	24226	10/270	1	400250000
Q1	TRANS NPN 2N3904	04713	2N3904	1	528071000
Q2	TRANS PNP 2N5194	04713	2N5194	1	528137000
Q3	TRANS NPN 2N5191	04713	2N5191	1	528136000
Q4	TRANS NPN 2N3904	04713	2N3904	1	528071000
Q5	TRANS NPN 2N3866	04713	2N3866	1	528116000
Q6-8	TRANS PNP 2N5194	04713	2N5194	3	528137000
Q9	TRANS NPN 2N5191	04713	2N5191	1	528136000
R1	RES MF 47.5K 1% 1/4W	19701	5043ED47K50F	1	341465000
R2	RES MF 150 OHM 1% 1/4W	19701	5043ED150R0F	1	341217000
R3	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R4	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R5	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R6	RES MF 681 OHM 1% 1/4W	19701	5043ED681R0F	1	341280000
R7	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R8	RES MF 49.9 OHM 1% 1/4W	19701	5043ED49R90F	1	341167000
R9	RES MF 221 OHM 1% 1/4W	19701	5043ED221R0F	1	341233000
R10	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R11	RES VAR 1M 10% 0.5W	73138	72XWR1M	1	31142300A
R12-13	RES MF 499K 1% 1/4W	19701	5043ED499K0F	2	341567000
R14-15	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	2	341400000
R16	RES COMP 12M 5% 1/4W	01121	CB1265	1	343708000
R17	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R18	RES MF 1.21K 1% 1/4W	19701	5043ED1K210F	1	341308000
R19-22	RES MF 200 OHM 1% 1/4W	19701	5043ED200R0F	4	341229000
R23	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R24	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R25	RES MF 96.25 OHM 0.1% 1/2W	64537	PME65-T2	1	326996000
R26	RES MF 71.15 OHM 0.1% 1/2W	64537	PME65-T2	1	326997000
R27	RES MF 96.25 OHM 0.1% 1/2W	64537	PME65-T2	1	326996000
R28	RES MF 8.25K 1% 1/4W	19701	5043ED8K250F	1	341388000
R29	RES MF 3.01K 1% 1/4W	19701	5043ED3K010F	1	341346000
R30	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000

TABLE 7-2. REPLACEABLE PARTS (Cont.)

04312700E PWA 30 MHz OSCILLATOR
MODEL: 4321/4322

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
R31	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R32	RES MF 61.11 OHM 0.1% 1/2W	64537	PME65-T2	1	326998000
R33	RES MF 247.5 OHM 0.1% 1/2W	64537	PME65-T2	1	326995000
R34	RES MF 61.11 OHM 0.1% 1/2W	64537	PME65-T2	1	326998000
R35	RES MF 6.81K 1% 1/4W	19701	5043ED6K810F	1	341380000
R36	RES MF 3.01K 1% 1/4W	19701	5043ED3K010F	1	341346000
R37	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R38	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	1	341300000
R39	RES MF 61.11 OHM 0.1% 1/2W	64537	PME65-T2	1	326998000
R40	RES MF 247.5 OHM 0.1% 1/2W	64537	PME65-T2	1	326995000
R41	RES MF 30.56 OHM 0.1% 1/2W	64537	PME65-T2	1	32699200A
R42	RES MF 247.5 OHM 0.1% 1/2W	64537	PME65-T2	1	326995000
R43	RES MF 61.11 OHM 0.1% 1/2W	64537	PME65-T2	1	326998000
R44	RES MF 6.19K 1% 1/4W	19701	5043ED6K190F	1	341376000
R45	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R46	RES MF 49.9 OHM 1% 1/4W	19701	5043ED49R90F	1	341167000
R47	RES MF 3.01K 1% 1/4W	19701	5043ED3K010F	1	341346000
R48	RES MF 100 OHM 1% 1/4W	19701	5043ED100R0F	1	341200000
R49	RES MF 1.50K 1% 1/4W	19701	5043ED1K500F	1	341317000
RT1	THERMISTOR 1.0K DISK RDL LEADS	00241	JB31J1	1	32501700A
U1	IC OP-16GJ OP AMP	06665	OP-16GJ	1	535048000
Y1	CRYSTAL 30 MHz QTZ 3RD HC-43/U	32897	30MHz HC18/Y	1	547037000

04312800A PWA INTERFACE 30 MHZ
MODEL: 4321/4322

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
J43	SOCKET IC 16 PIN	06776	ICH-163-S3-G	1	473042000

TABLE 7-2. REPLACEABLE PARTS (Cont.)

04313200A — 50 MHz CALIBRATOR ASSY
MODEL: 4323/4324

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
A1	PWA 50 MHZ CALIBRATOR	04901	04313100A	1	04313100A
C6	CAP FT 1000pF 20% 500V	TUSONX	2499-003-X5S0102M	1	227105000
J42	CONNECTOR TYPE "N"	24253	4839	1	47945500A
W26	CABLE ASSEMBLY 2 CONNECTOR	04901	57222904A	1	57222904A

04313100A — PWA 50 MHZ CALIBRATOR
MODEL: 4323/4324

REFERENCE DESIGNATOR	DESCRIPTION	FED. CODE	MANUFACTURER PART NUMBER	QTY	BEC PART NUMBER
AR1	IC 301A OP AMP	27014	LM301AN	1	535012000
C1	CAP CER 470pF 10% 500V	33883	TYPE JF	1	224219000
C2	CAP MICA 100pF 5% 300V	20307	DM5-FC101J	1	205006000
C3	CAP EL 10uF 20% 25V	54217	SM-25-VB-10-M	1	283336000
C4	CAP VAR CER 3.5-18pF 250V	91293	9373	1	281011000
C5	CAP CER 1000pF 10% 600V	16546	CE-102	1	224310000
C7	CAP EL 10uF 20% 25V	54217	SM-25-VB-10-M	1	283336000
C8	CAP CER 0.01uF 100V	33883	BT Z5U	1	224119000
C9	CAP MICA 36pF 5% 300V	14655	CD5EC360J	1	205003000
C10	CAP MICA 200pF 5% 100V	14655	CD5FA201J	1	205024000
C11	CAP MICA 10pF 5% 300V	14655	CD5WCC100J	1	205002000
C12	CAP VAR CER 3.5-18pF 250V	91293	9373	1	281011000
CR1-2	DIODE HSCH1001 (1N6263)	28480	HSCH-1001	2	530174000
CR3	DIODE MV-1650	04713	MV1650	1	530762000
L1	INDUCTOR 4.7uH 10%	24226	10/471	1	400384000
L2	INDUCTOR 0.56uH 10%	24226	10/560	1	400382000
L3	INDUCTOR 0.022 uH	04901	40044400A	1	40044400A
Q1	TRANS NPN 2N3904	04713	2N3904	1	528071000
R1	RES MF 1.50K 1% 1/4W	19701	5043ED1K500F	1	341317000
R2-3	RES MF 100K 1% 1/4W	19701	5043ED100K0F	2	341500000
R4	RES VAR 1K 10% 0.5W	32997	3299X-1-102	1	311410000
R6	RES MF 100K 1% 1/4W	19701	5043ED100K0F	1	341500000
R7	RES MF 2.43K 1% 1/4W	19701	RN55D-2431-F	1	341337000
R8-9	RES MF 1.00K 1% 1/4W	19701	5043ED1K000F	2	341300000
R10	RES MF 10.0K 1% 1/4W	19701	5043ED10K00F	1	341400000
R11	RES MF 5.11K 1% 1/4W	19701	5043ED5K110F	1	341368000
R12	RES MF 1.21K 1% 1/4W	19701	5043ED1K210F	1	341308000
R13	RES MF 1.30K 1% 1/4W	19701	5043ED1K300F	1	341311000
R14	RES MF 75.0 OHM 1% 1/4W	19701	5043ED75R00F	1	341184000
R15	RES MF 50 OHM 0.1% 1/4W	64537	PME55-T0	1	325916000
U1	IC AD581JH VOLT REF	51640	AD581JH	1	535053000

SECTION 8
SCHEMATIC DIAGRAMS

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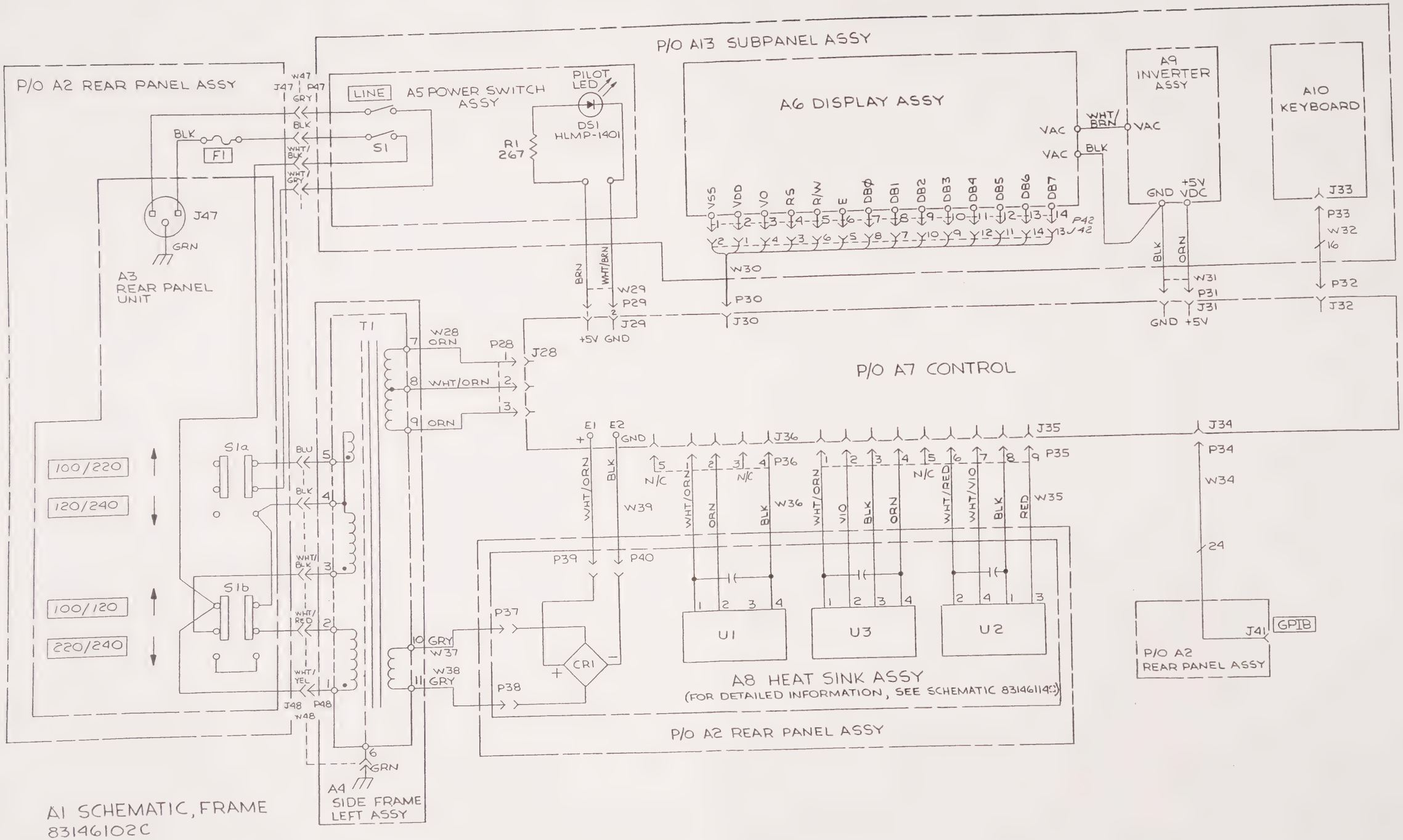
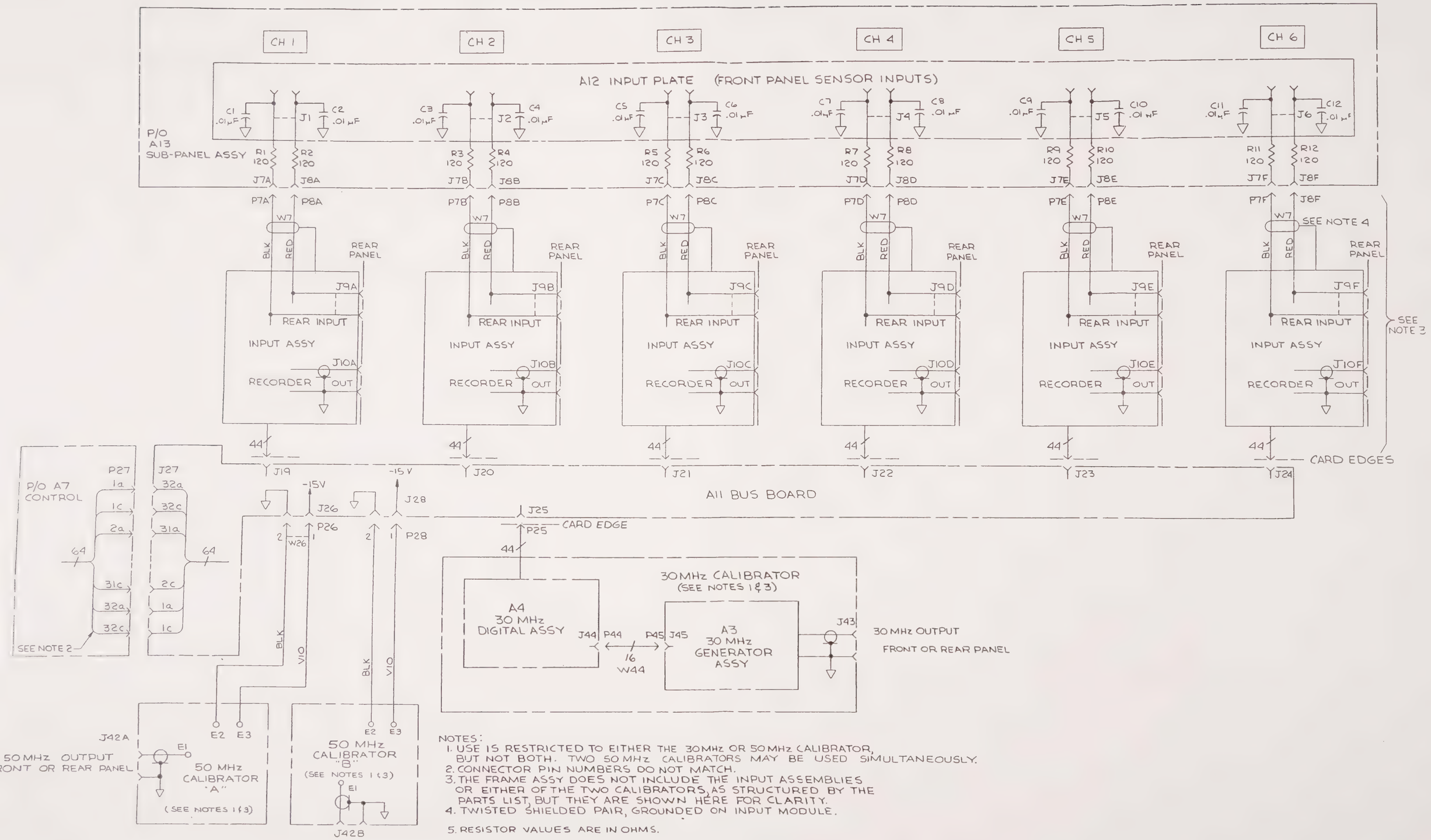


NOTES:

1. o-DENOTES SOLDER CONNECTION.
2. [ ]-SOLID BOXES DENOTE EXTERNAL MARKINGS.

Figure 8-1. Frame Schematic, Sh 1 of 2
83146102C



NOTES:
1. USE IS RESTRICTED TO EITHER THE 30MHz OR 50MHz CALIBRATOR, BUT NOT BOTH. TWO 50 MHz CALIBRATORS MAY BE USED SIMULTANEOUSLY.
2. CONNECTOR PIN NUMBERS DO NOT MATCH.
3. THE FRAME ASSY DOES NOT INCLUDE THE INPUT ASSEMBLIES OR EITHER OF THE TWO CALIBRATORS, AS STRUCTURED BY THE PARTS LIST, BUT THEY ARE SHOWN HERE FOR CLARITY.
4. TWISTED SHIELDED PAIR, GROUNDED ON INPUT MODULE.
5. RESISTOR VALUES ARE IN OHMS.

Figure 8-2. Frame Schematic, Sh 2 of 2
83146103D

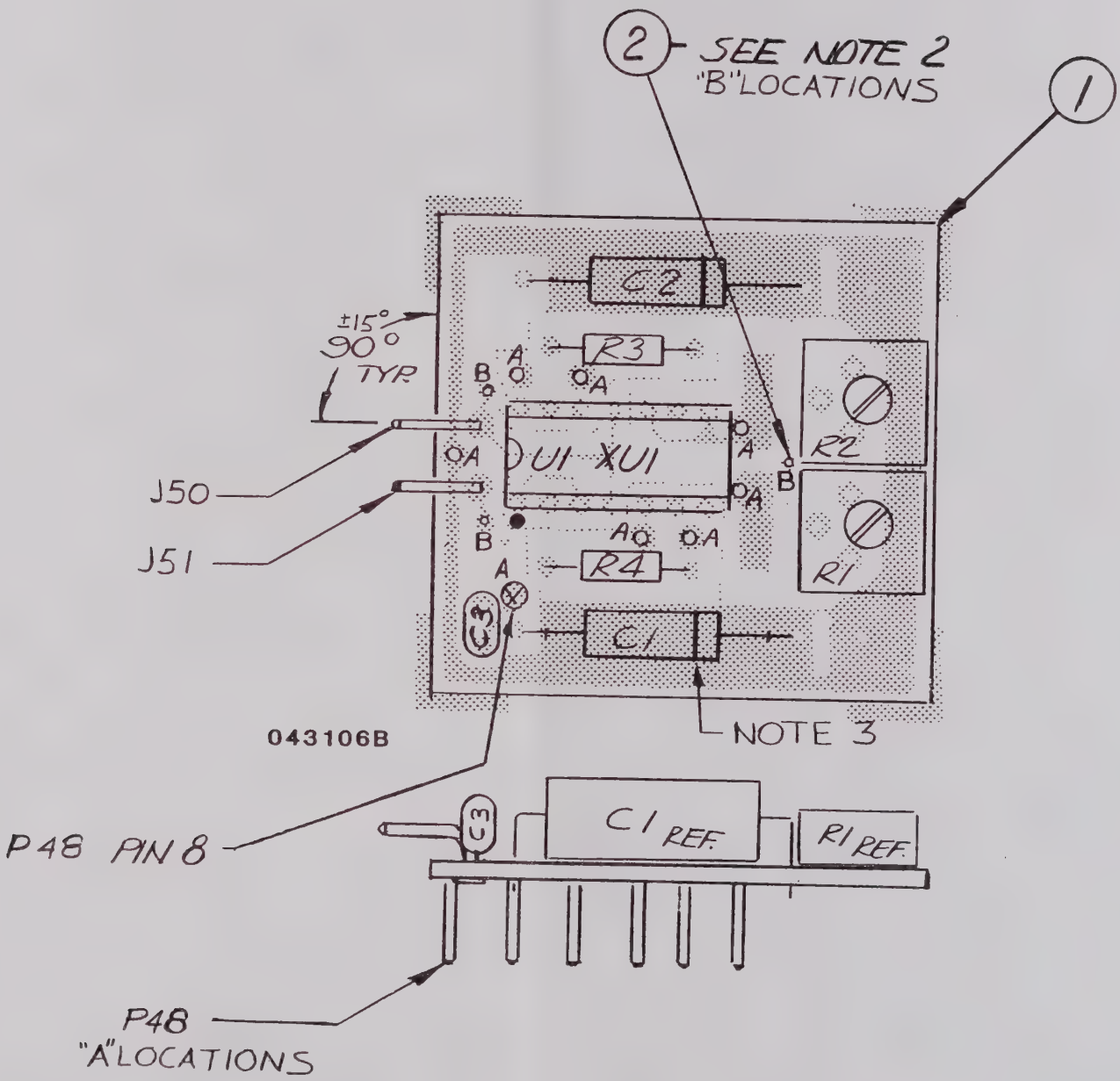
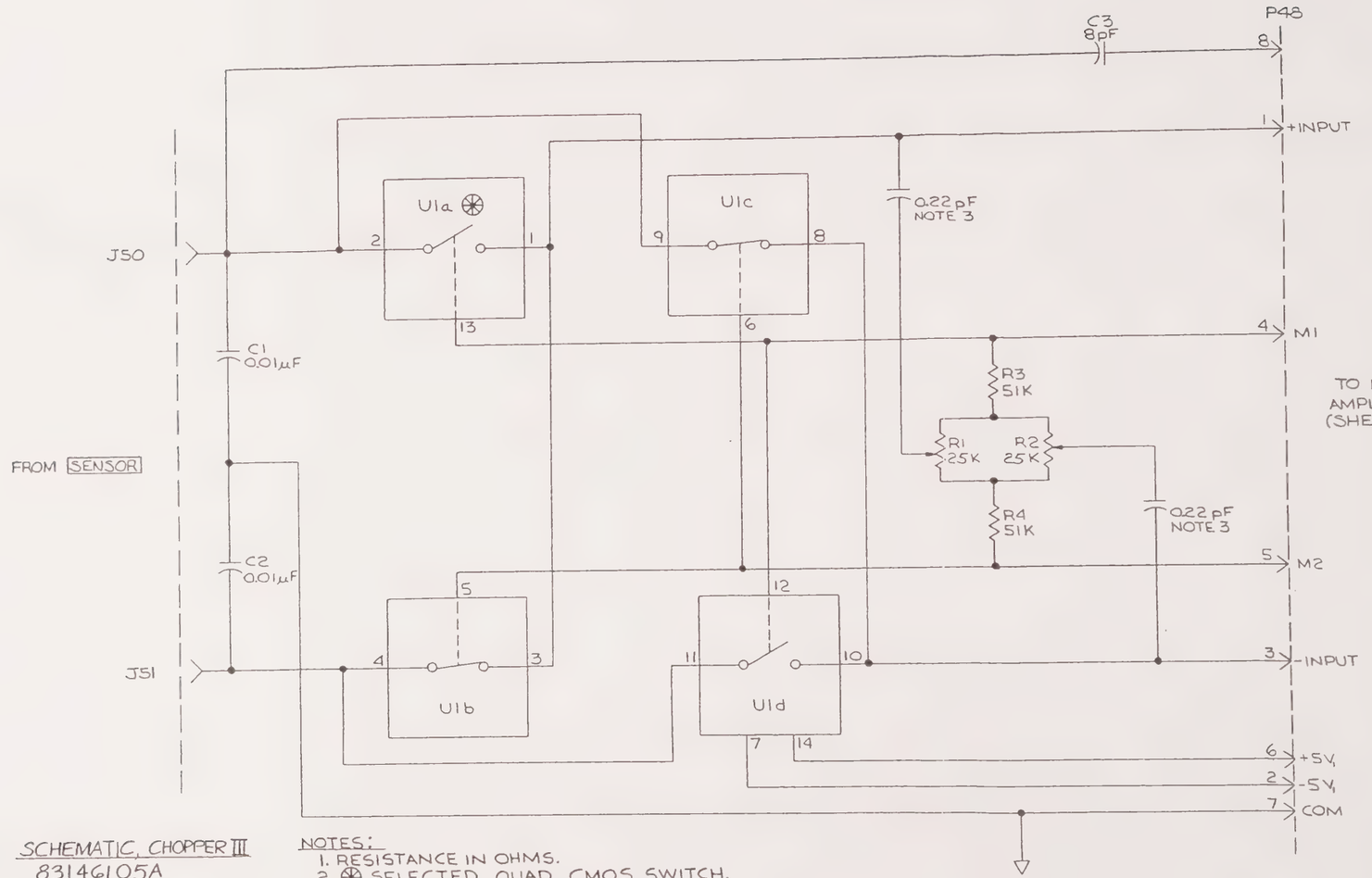


Figure 8-3. Chopper II Component Location
043106

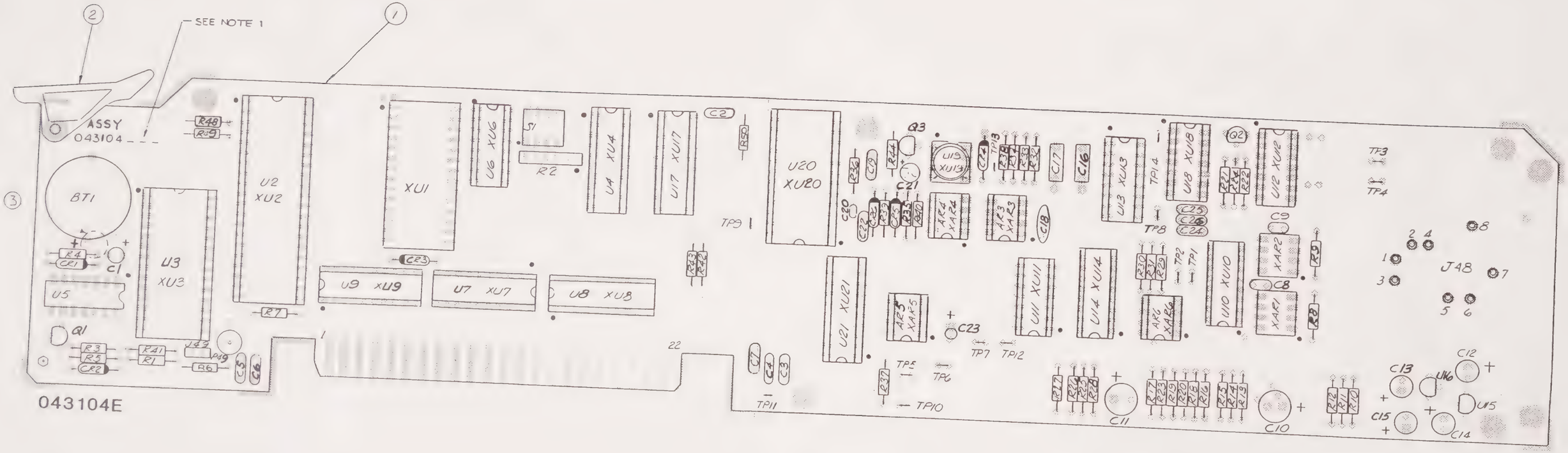


SCHEMATIC, CHOPPER III
83146105A

NOTES:
1. RESISTANCE IN OHMS.
2. ⊛ SELECTED QUAD CMOS SWITCH.
3. CAP IS PART OF PWB CIRCUITRY.

4. LAST NUMBERS USED: J51, U1, R4, C3

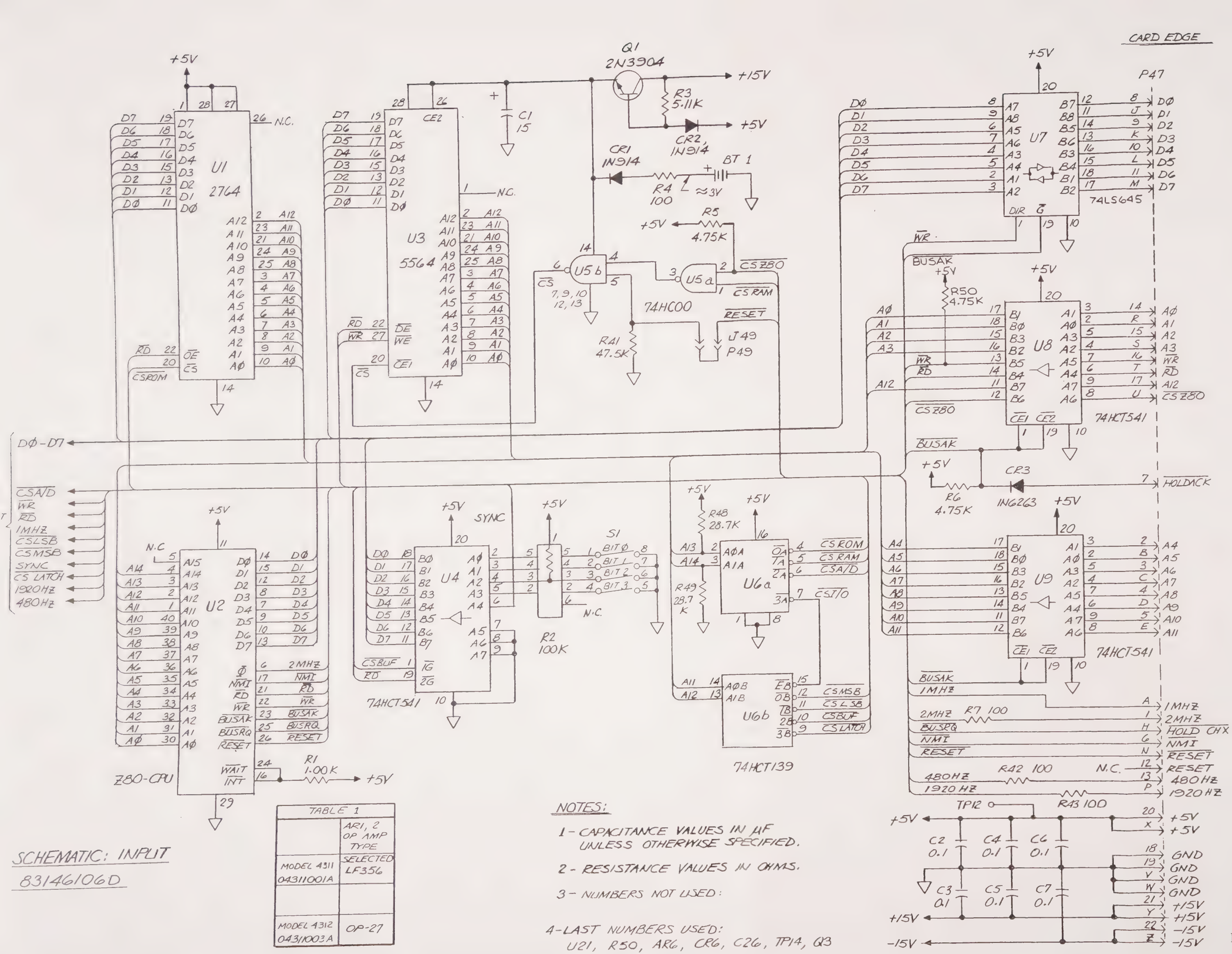
Figure 8-4. Chopper II Schematic
83146104C



NOTES

1. MARK "FINAL" ASSY. PART NUMBER WITH 1/8" HIGH BLACK CHARACTERS. REFER TO MANUFACTURING ORDER FOR COMPLETE PART NUMBER.

Figure 8-5. Input Component Location
04310400E



SCHEMATIC: INPUT
83146106D

TABLE 1	
	AR1, 2 OP AMP TYPE
MODEL 4311 04311001A	SELECTED LF356
MODEL 4312 04311003A	OP-27

NOTES:

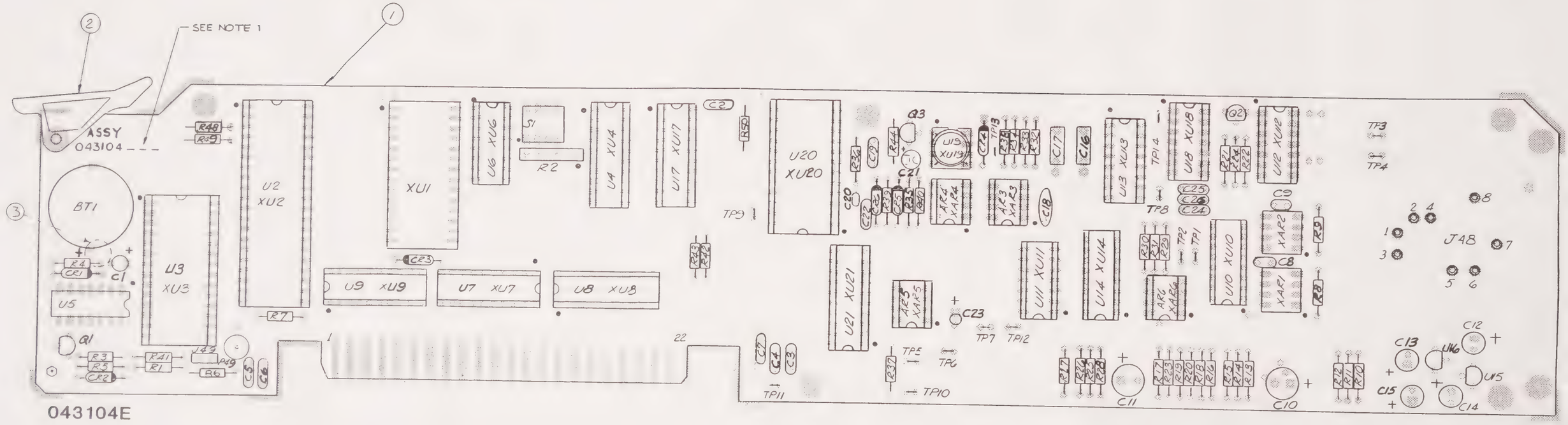
1 - CAPACITANCE VALUES IN μF UNLESS OTHERWISE SPECIFIED.

2 - RESISTANCE VALUES IN OHMS.

3 - NUMBERS NOT USED:

4 - LAST NUMBERS USED:
U21, R50, AR6, CR6, C26, TP14, Q3

Figure 8-6. Input Schematic, Sh 1 of 2
83146106D



NOTES:

1. MARK "FINAL" ASSY. PART NUMBER WITH 1/8" HIGH BLACK CHARACTERS. REFER TO MANUFACTURING ORDER FOR COMPLETE PART NUMBER.

Figure 8-7. Input Component Location
04310400E

SCHEMATIC: INPUT
83146107F

Figure 8-8. Input Schematic, Sh 2 of 2
83146107F

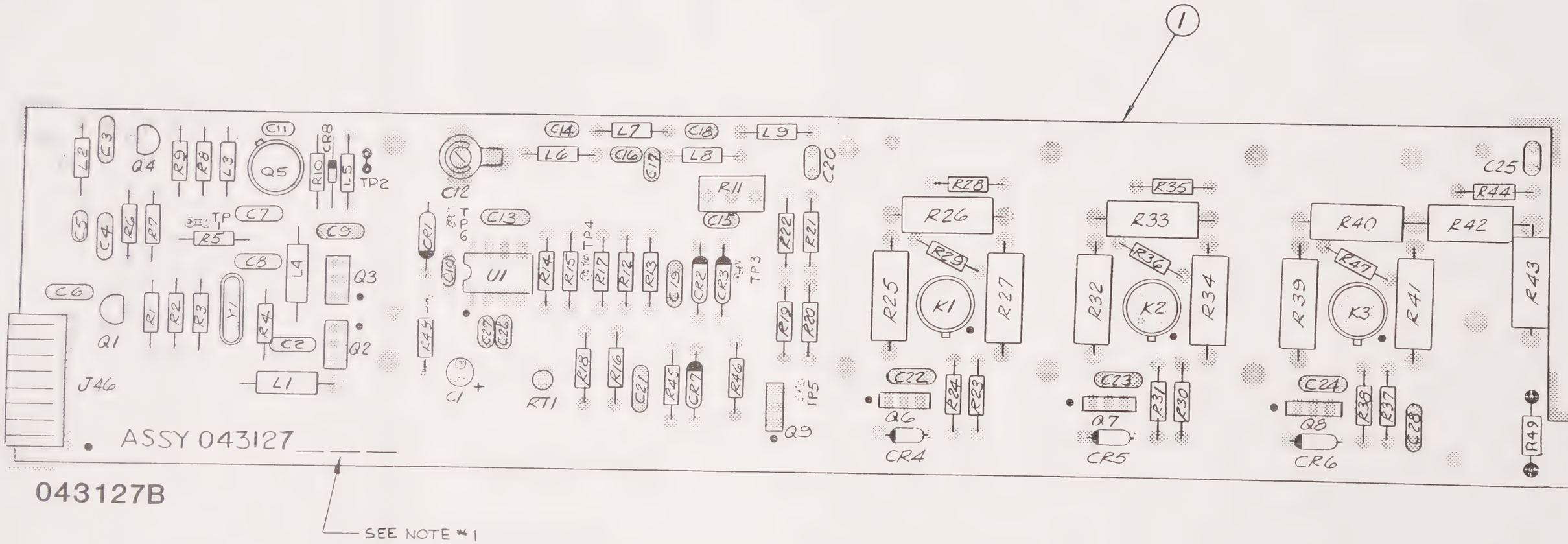
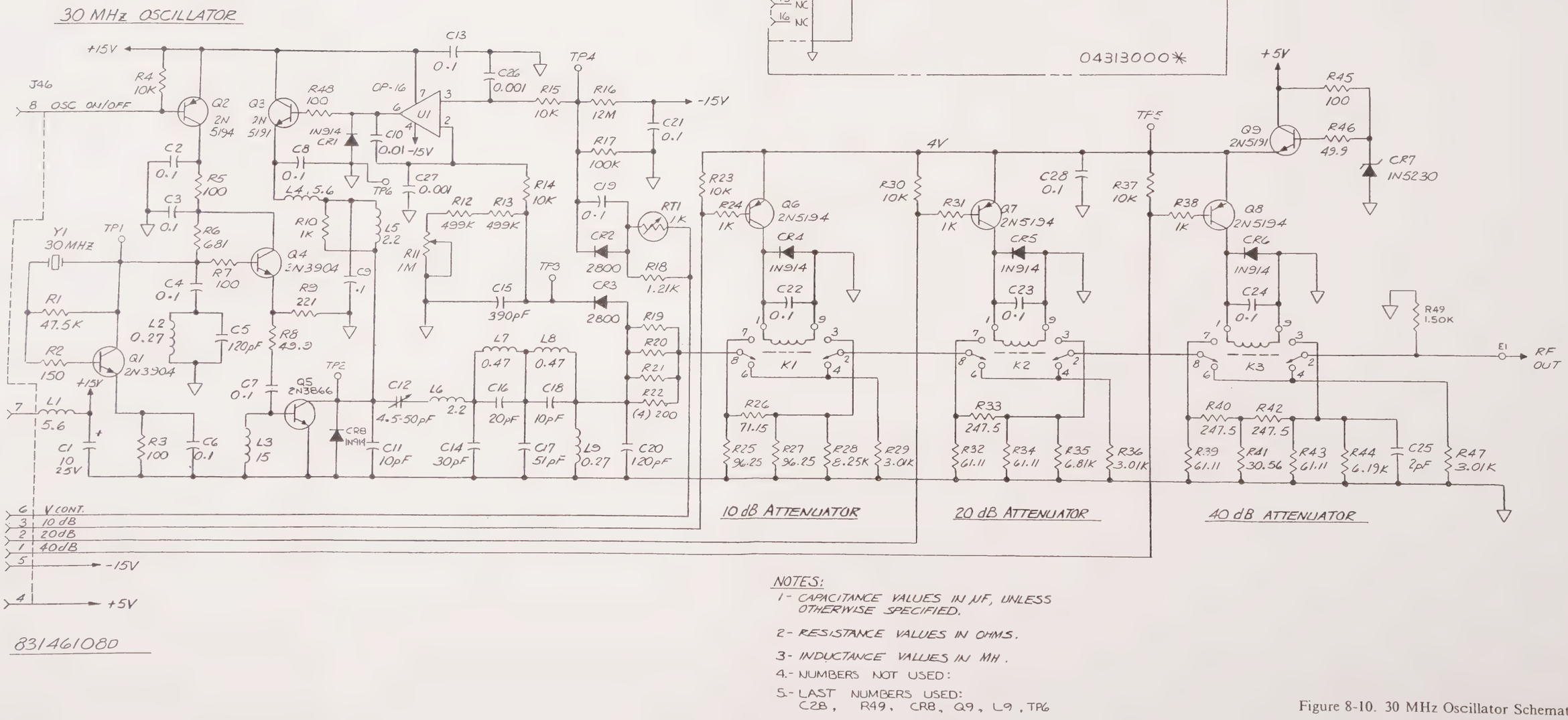


Figure 8-9. 30 MHz Oscillator Component Location
04312700B



NOTES:

1- CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.

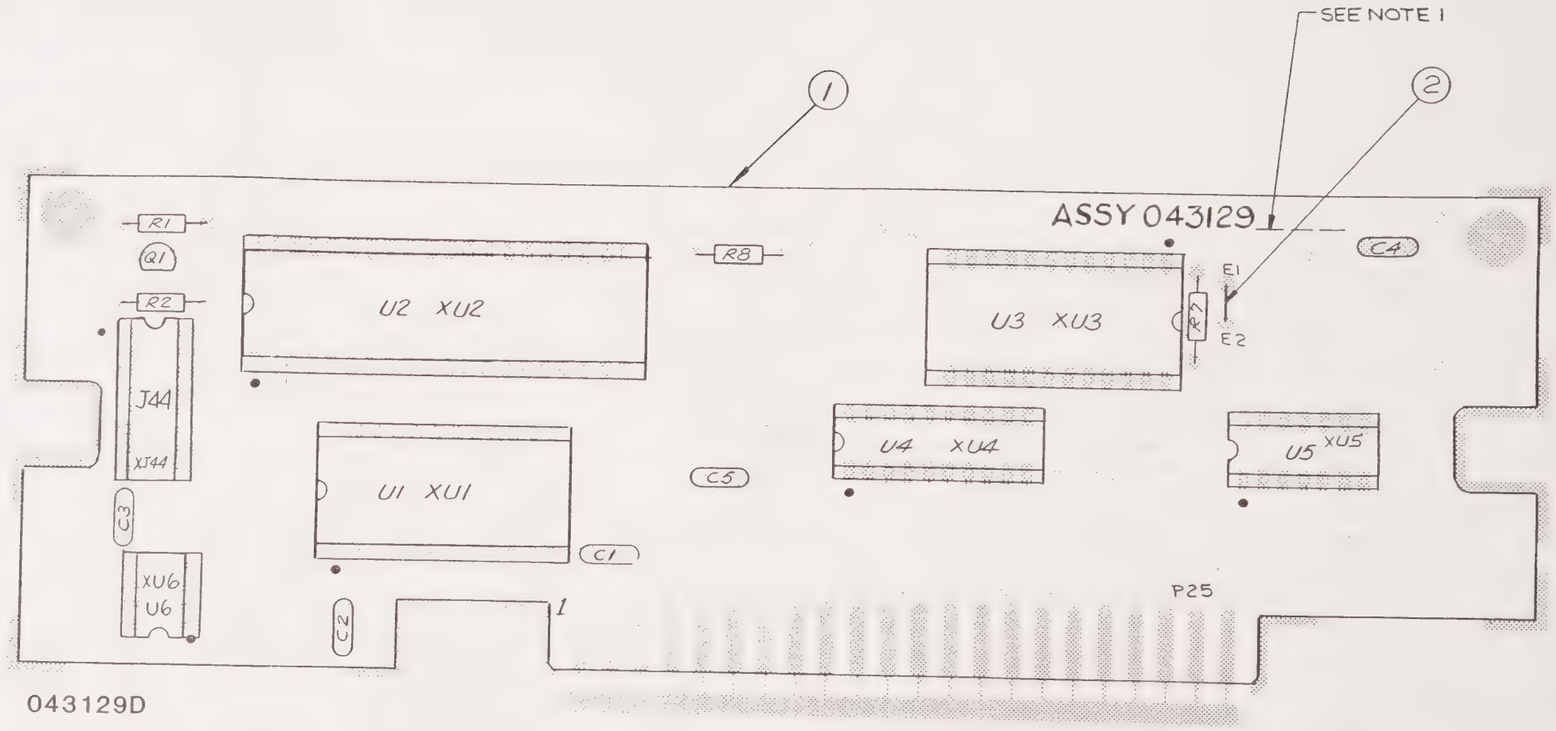
2- RESISTANCE VALUES IN OHMS.

3- INDUCTANCE VALUES IN MH.

4.- NUMBERS NOT USED:

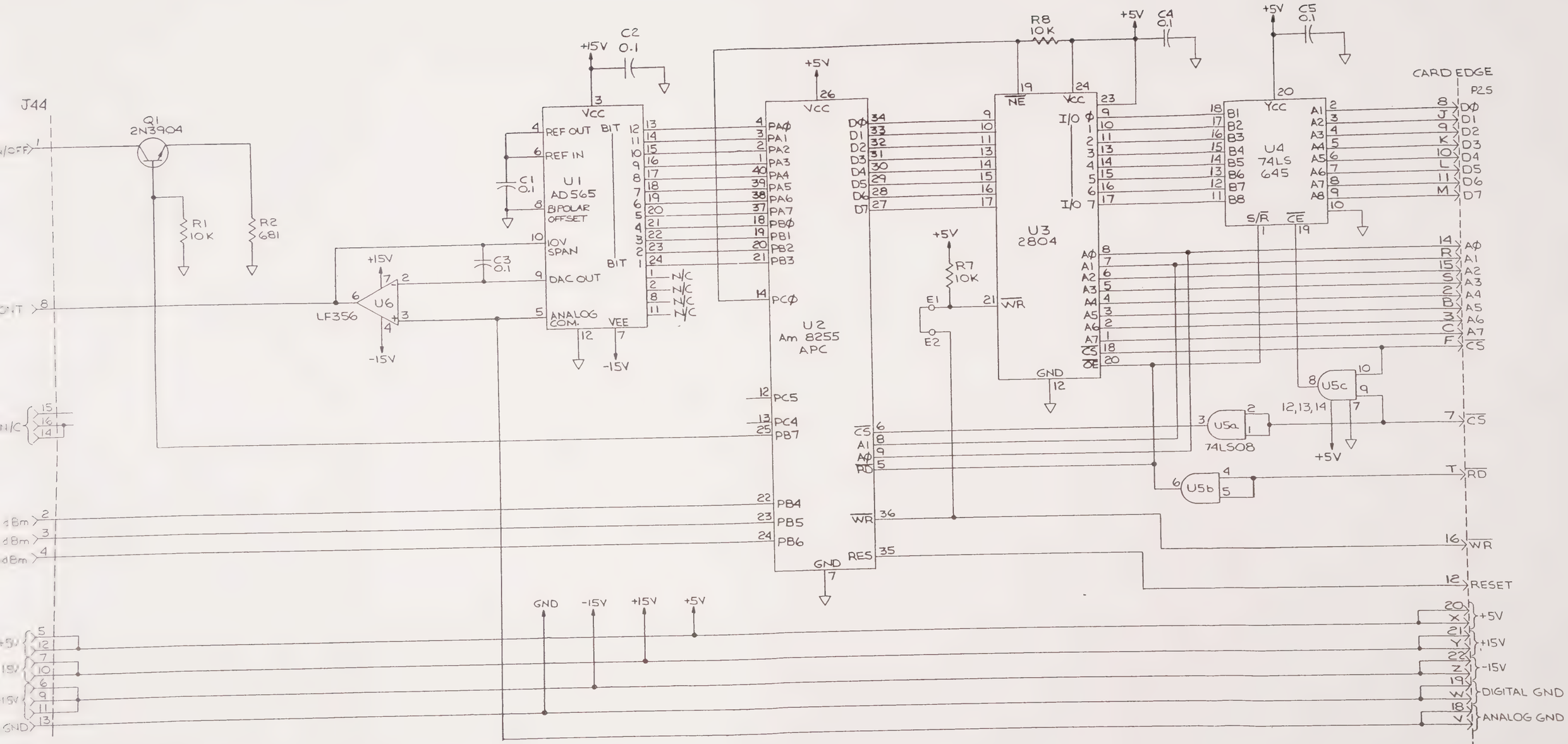
5.- LAST NUMBERS USED:
C28, R49, CR8, Q9, L9, TP6

Figure 8-10. 30 MHz Oscillator Schematic
83146108D



NOTE:
1. MARK "FINAL" ASSY PART NUMBER WITH 1/8" HIGH BLACK CHARACTERS. REFER TO MANUFACTURING ORDER FOR COMPLETE PART NUMBER.

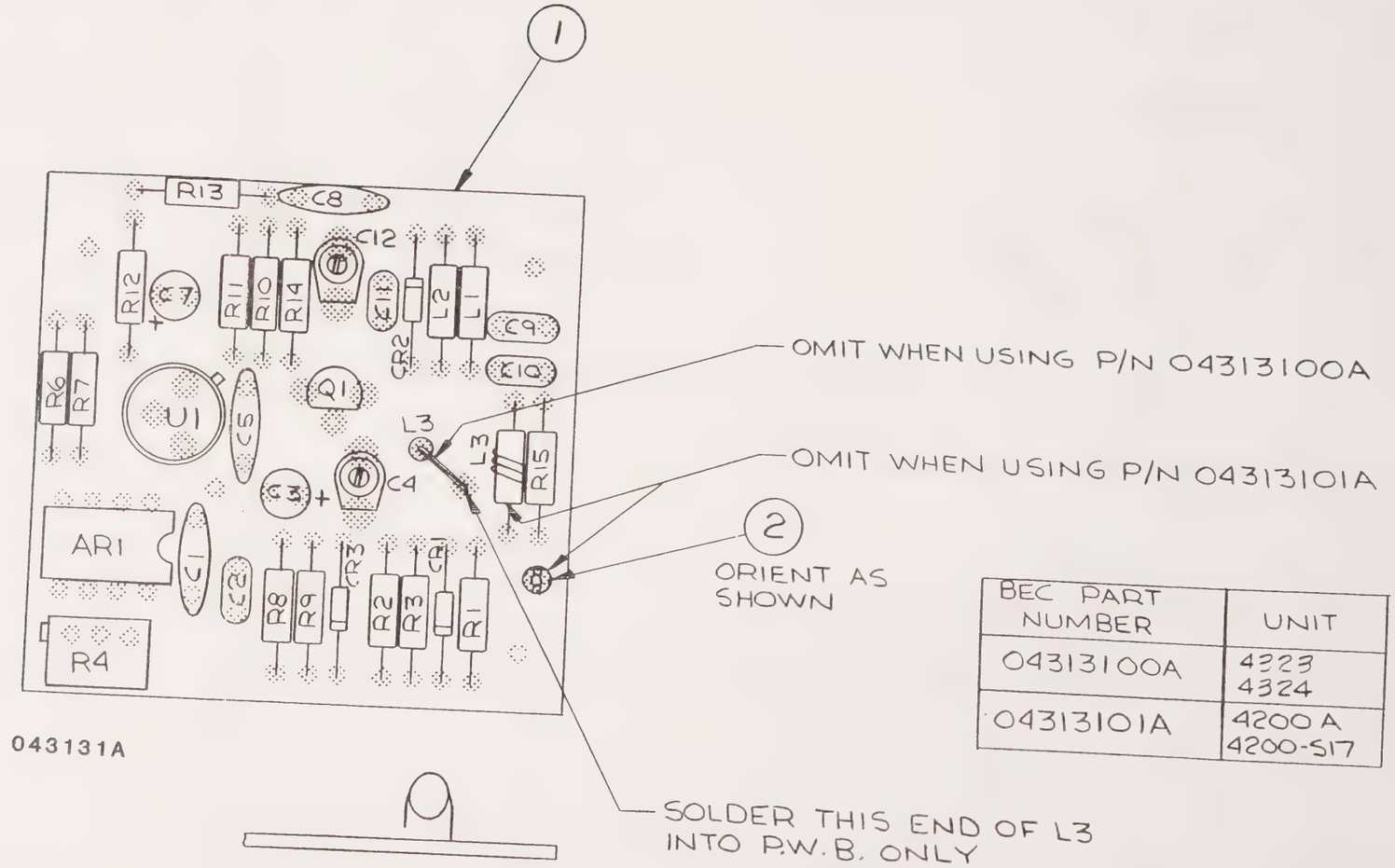
Figure 8-11. 30 MHz Digital Component Location
04312900D



SCHEMATIC, 30MHz DIGITAL
83146109B

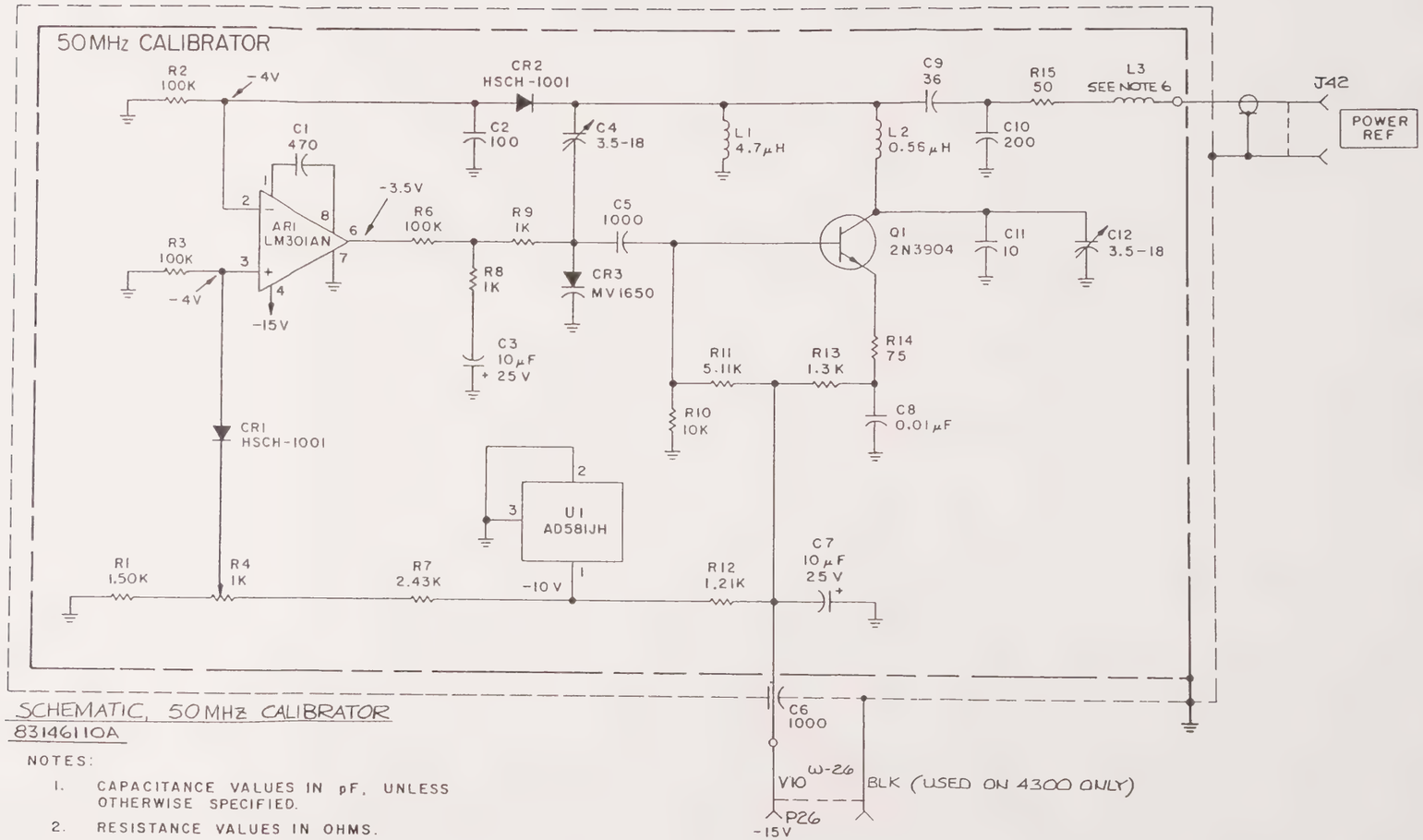
NOTES:
1. CAPACITANCE VALUES IN μF UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. LAST NUMBERS USED:
   R8, C5, U6

Figure 8-12. 30 MHz Digital Schematic
83146109B



BEC PART NUMBER	UNIT
04313100A	4323 4324
04313101A	4200 A 4200-S17

Figure 8-13. 50 MHz Calibrator Component Location 04313100A



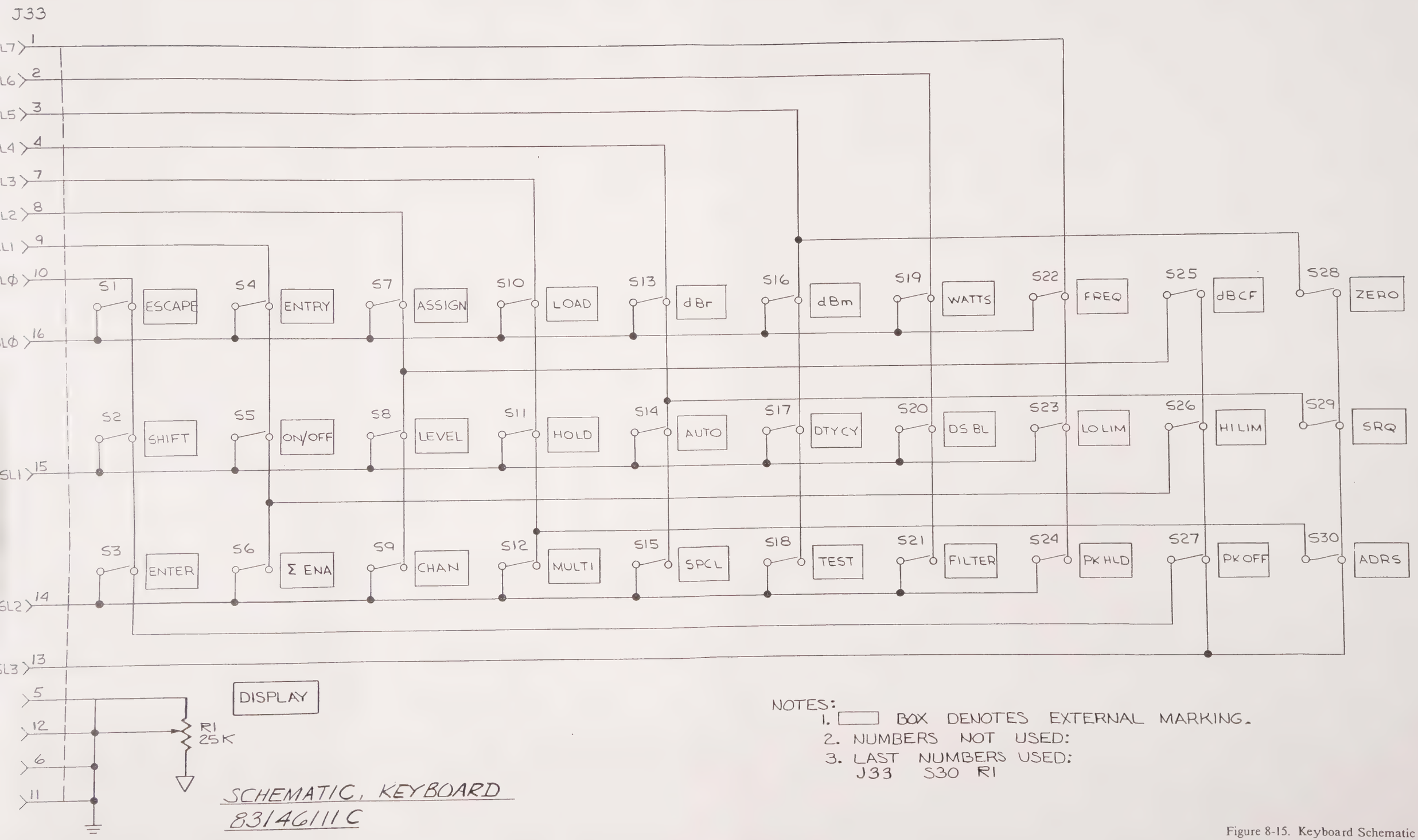
SCHEMATIC, 50MHz CALIBRATOR
83146110A

NOTES:

1. CAPACITANCE VALUES IN pF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. [ ] EXTERNAL MARKINGS.
4. LAST NUMBERS USED:
   C12 R15
5. NUMBERS NOT USED: R5
6. L3-.022μH USED ON 4300
   .033μH USED ON 4200A & 4200517

Figure 8-14. 50 MHz Calibrator Schematic
83146110A

R11
C15
(C23)



SCHEMATIC, KEYBOARD
83146111C

NOTES:
1. ☐ BOX DENOTES EXTERNAL MARKING.
2. NUMBERS NOT USED:
3. LAST NUMBERS USED:
   J33 S30 R1

Figure 8-15. Keyboard Schematic
83146111C

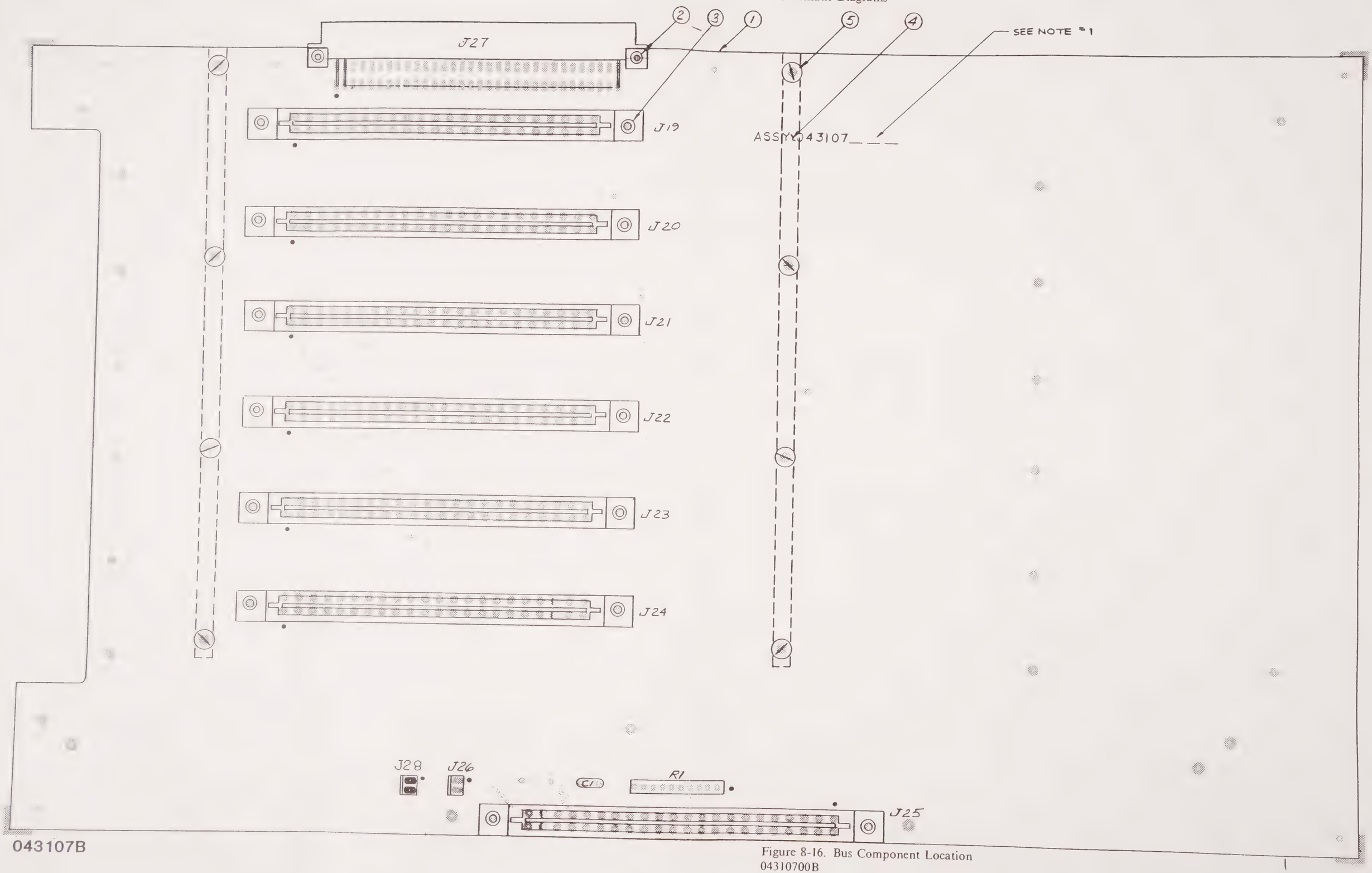
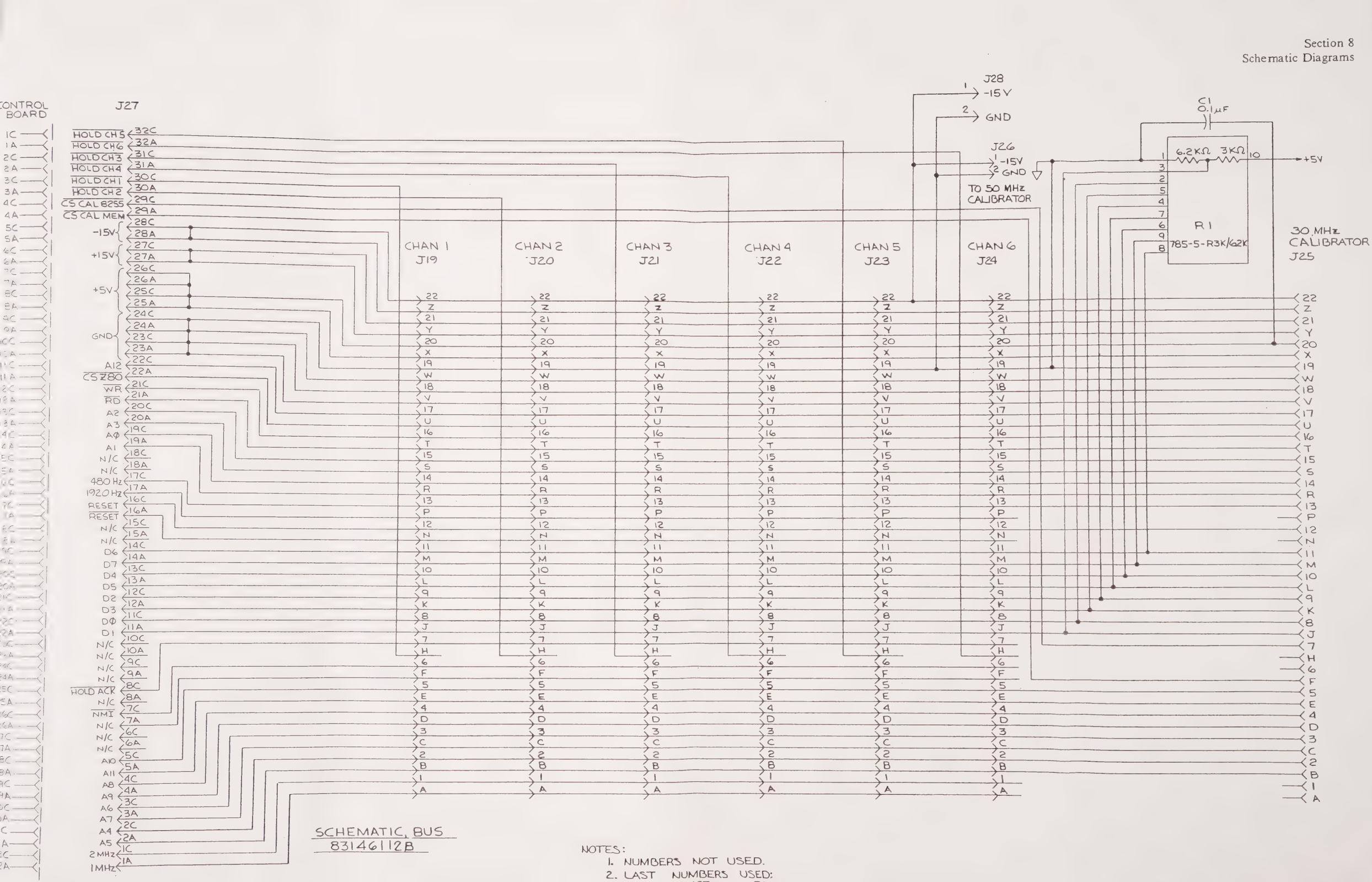


Figure 8-16. Bus Component Location
04310700B



SCHEMATIC, BUS
83146112B

NOTES:
1. NUMBERS NOT USED.
2. LAST NUMBERS USED:
C1, U27, R1

Figure 8-17. Bus Schematic 83146112B

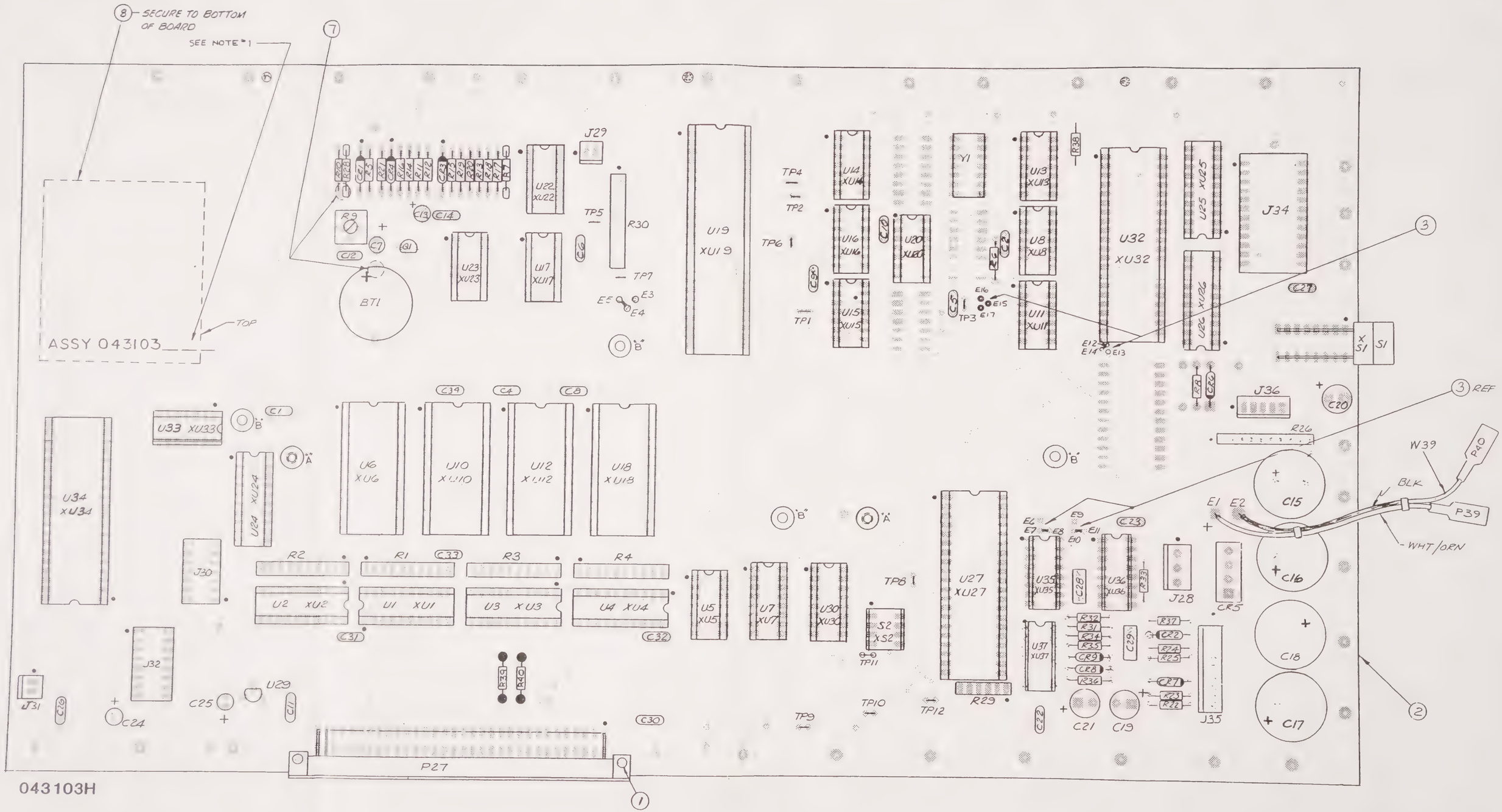
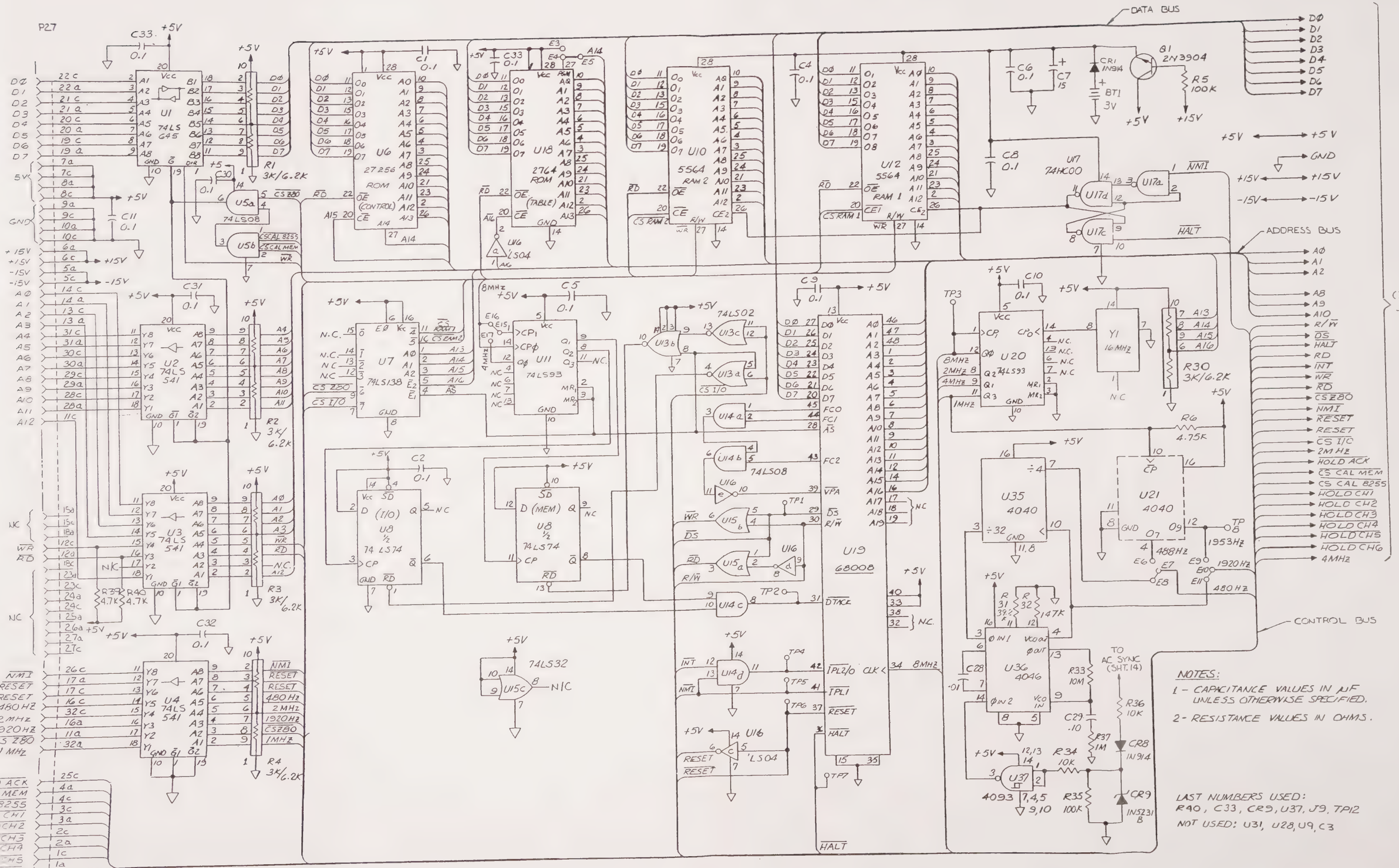


Figure 8-18. Control Component Location
04310300H



NOTES:

1 - CAPACITANCE VALUES IN µF UNLESS OTHERWISE SPECIFIED.

2 - RESISTANCE VALUES IN OHMS.

LAST NUMBERS USED:
R40, C33, CR9, U37, J9, TP12
NOT USED: U31, U28, U9, C3

SCHEMATIC CONTROL
83146113F

Figure 8-19. Control Schematic, Sh 1 of 3
83146113F

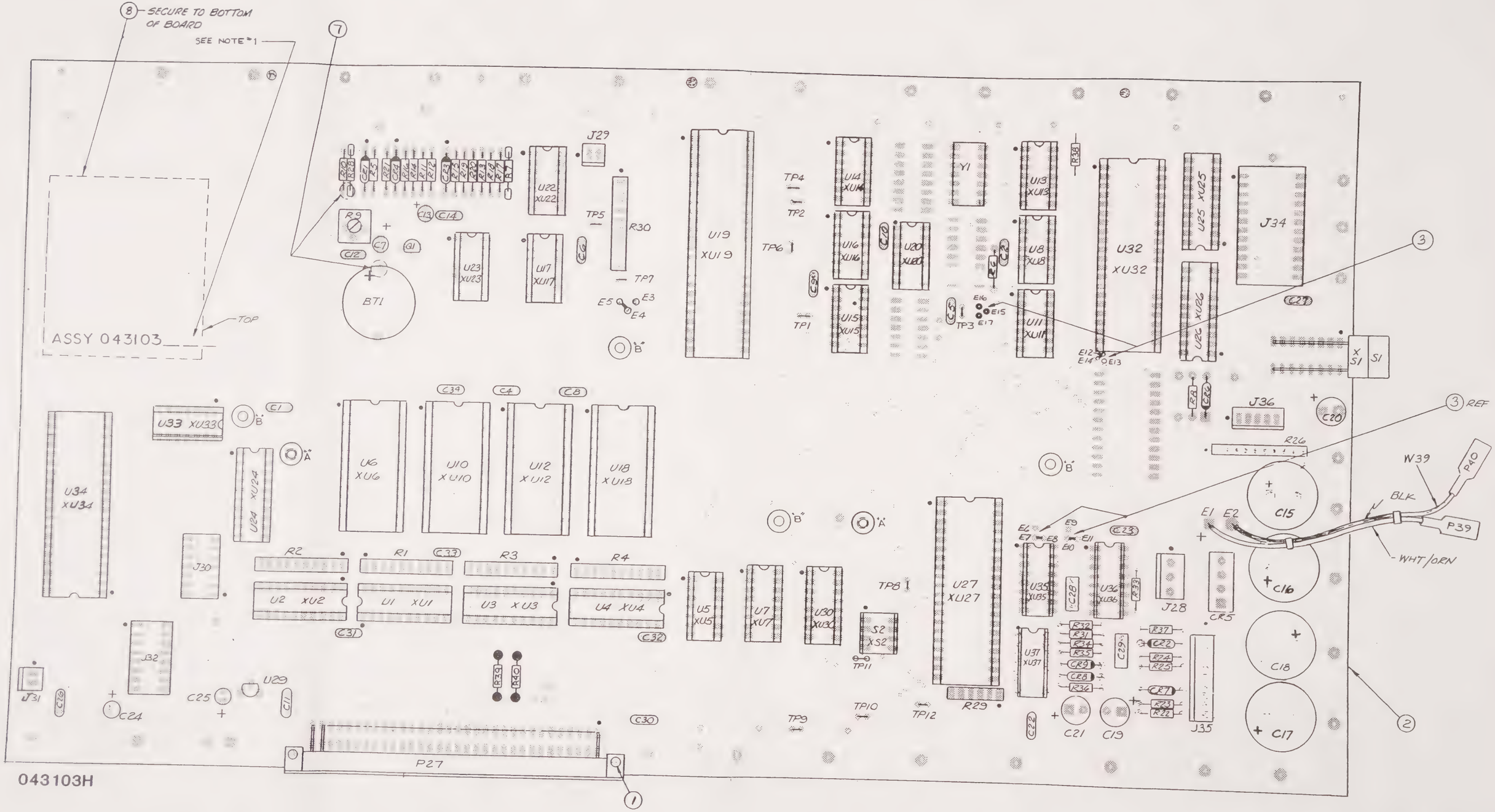
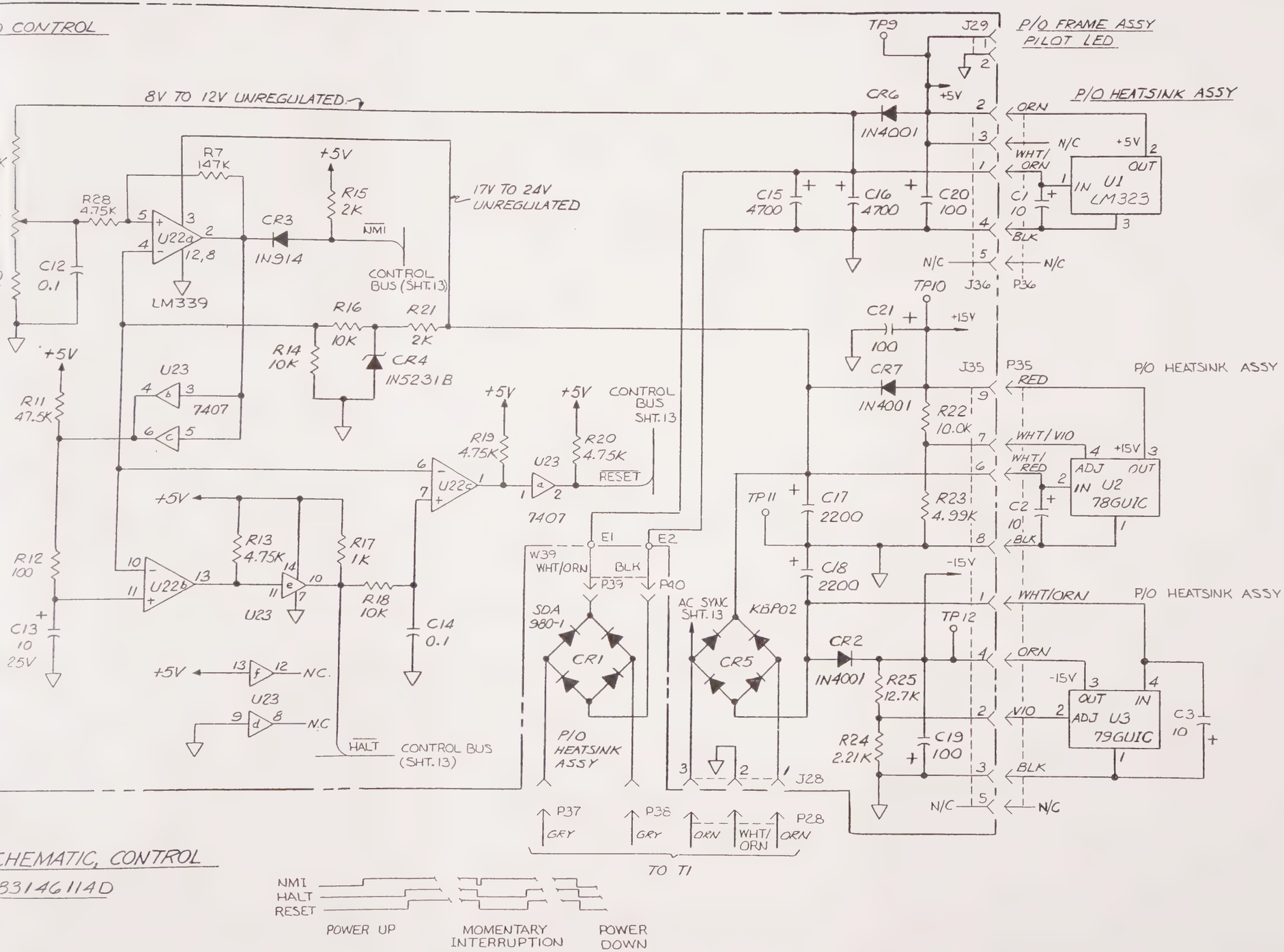


Figure 8-20. Control Component Location
04310300H



NOTES:
1. CAPACITANCE VALUES IN μF UNLESS OTHERWISE SPECIFIED
2. RESISTANCE VALUES IN OHMS.
3. NUMBERS NOT USED: U31, U28, U9, C3
4. LAST NUMBERS USED: R40, C33, CR9 U37 J9, TP12

CHEMATIC, CONTROL
83146114D

Figure 8-21. Control Schematic, Sh 2 of 3
83146114D

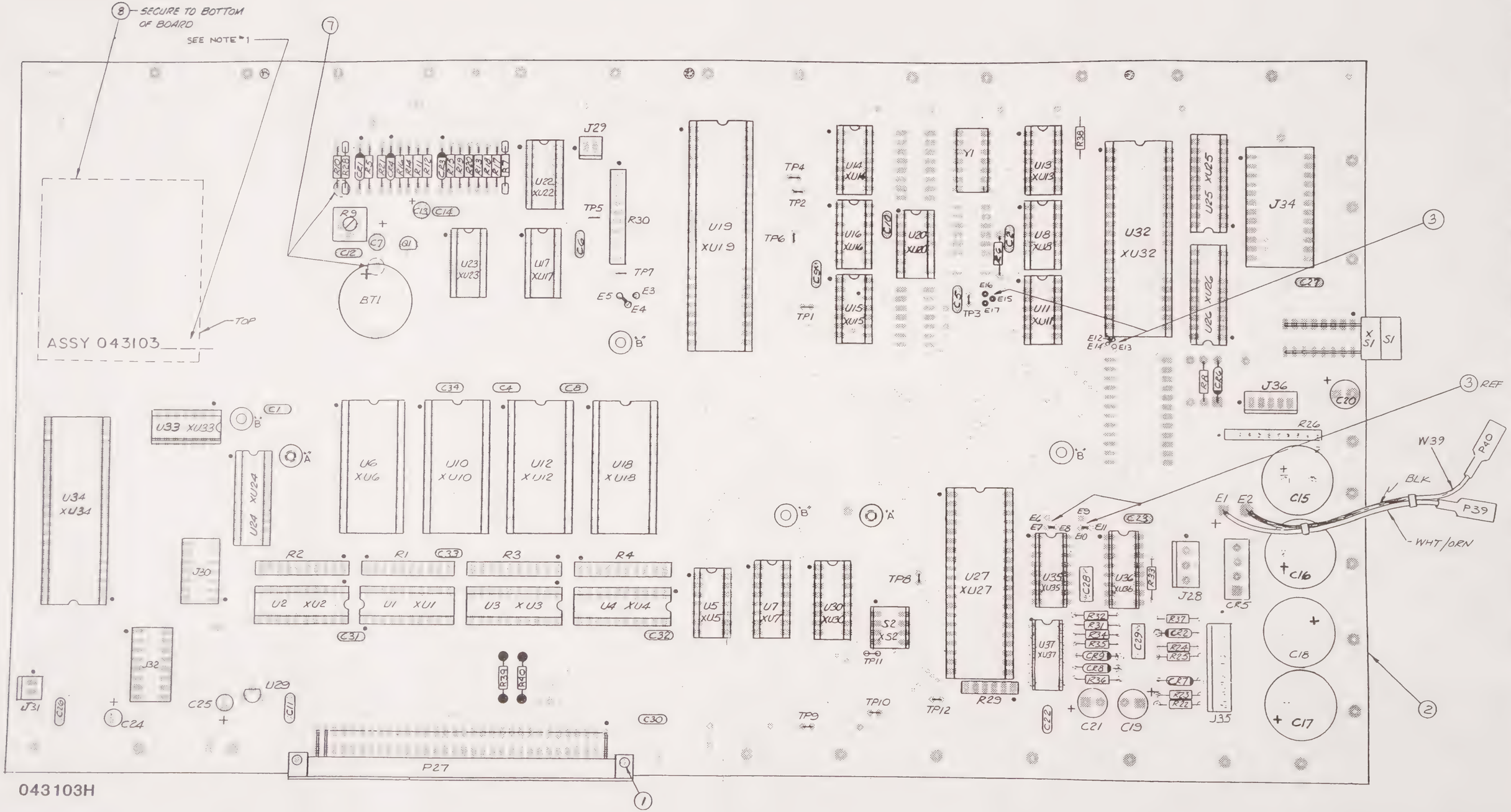
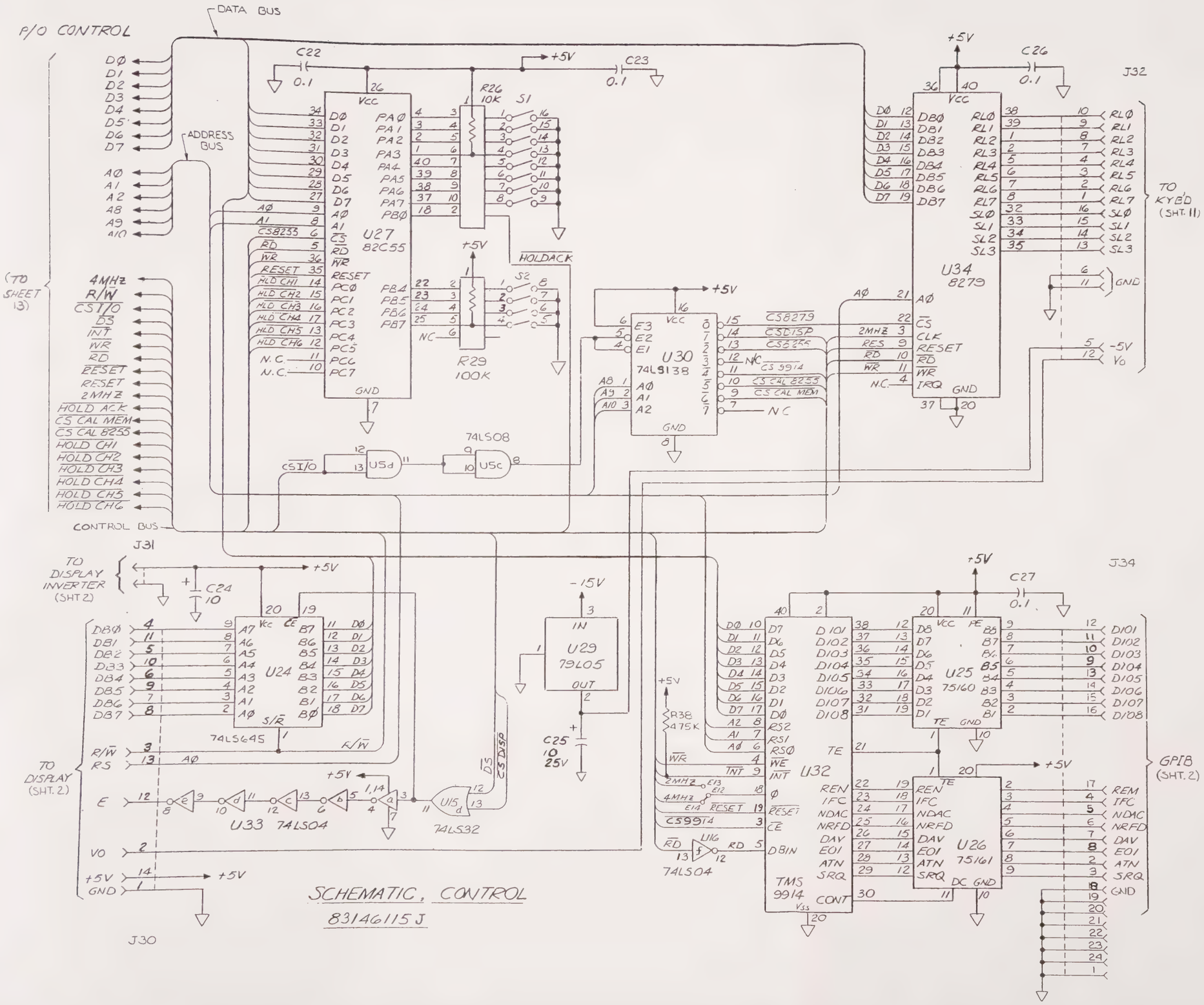


Figure 8-22. Control Component Location
04310300H



NOTES:
1. CAPACITANCE VALUES IN μF UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. NUMBERS NOT USED: U31, U28, U9, C3
4. LAST NUMBERS USED: R40, C33, CR9 U37, J9, TP12

Figure 8-23. Control Schematic, Sh 3 of 3
83146115J

4300 MANUAL ADDENDUM

3-120. Change "nanowatts" to "milliwatts", and "nW" to "mW".

3-131. Change "DATAIN [5013,12345...." to "DATAIN [51013, 12345....".

3-133, item 4. Add the statement "Fifteen frequencies must be included in the statement, even if some of them have to be dummy frequencies, except for the final batch which loads points 76 through 80, or 31 through 35 as applicable."

4-2, item 1. In the second paragraph, change "HGz" to "GHz".

4-6. Add the following statement to the end of the section: "The uncertainty is calculated by U = (1 - PL * PS) **2 where PL and PS are the reflection coefficients of the load and source. The reflection coefficients are related to the SWR by:

P = (SWR - 1)/(SWR + 1).

4-7. Change "reponding" to "responding".

5-5, item 3. Change "Q2" to "Q3". Also, delete the sentence "The power output is linear ..."

6-5. Change item h to subsection 2 and title it "Boards and Modules."

6-114, item 7. Immediately after Table 6-106, the sentence "This completes verification of the 30 MHz calibrator" should be moved to the end of section 6-114.

6-114, item 11. Add the following to the end of the last paragraph: "The tolerances at -10 and below are tighter than what might be expected. This is because the autocalibration has been done. What is being measured is the difference in the internal attenuators compared to the external test attenuators. The 0 dBm reference does not get involved."

6-204, item 2. After the first sentence (Power up...), add "Then power down, set the Bit switch as shown in Table 6-205. Then power up."

6-206, item 10. Add the following paragraph after the Calendar entry step:

"MIDSCALE CORRECTION. At this point the 4300 will prompt the operator for a number between -15 and 15 which affects the midscale output on all ranges (the region from -3 to -7 dB from full scale on a given range). Note: This adjustment applies to software versions DL and higher (May 88). Press Enter if it is desired to not change the number at this time. The number affects the output by .005 dB per digit at -5 dB F.S., and progressively less at levels that deviate from this. The number is stored in non-volatile RAM. In general, this is the last step in the calibration process (see Step 18), done after the endpoints of the ranges are set. However, the access to this adjustment is put at the beginning of the Special 6 routine for ease of use when several passes at the number are required. When the number has been entered and Enter has been pressed, the Escape key may be pressed to exit the Special 6 routine. The num-

ber will be saved."

6-206, item 18. Change the entire paragraph to the following:

"MIDSCALE ADJUSTMENT: Set the 4300 and the reference to -25 dBm. Compare readings again. If the readings are different by .01 dB or more, press Special 6 and perform the midscale adjustment as described in Step 10 above. This adjustment does not affect any of the previous adjustments."

6-207, item 1. Add "or to NBS" after .015 dB in the second sentence.

6-207, item 8. Change EMP-1 to EPM-1. Also, add the following to the end of the paragraph: "Note: the downscale adjustment may affect the upscale levels (0, -10, -20, etc.). Perform step 5 above as required."

6-207, item 9. Draw a line under -60.00 in the example to indicate the addition process.

6-207, item 12. Change the paragraph to read as follows:

"MIDSCALE ADJUSTMENT: Take a reading at -5 dBm as before, using a 5 dB attenuator. If this point is in error by .01 dB or more, press Special 6 and perform the midscale adjustment as described in Step 10 of Section 6-206. This adjustment does not affect any of the full scale or downscale adjustments. Then perform the final check as shown in Section 6-206 paragraph 19."

Table 6-302. Delete the asterisk before the -60.

6-346, item 2. Change "crystals" to "crystal".

6-347. Change "16 to 24" to "16 to 24 V".

May 88

WARRANTY

Boonton Electronics Corporation warrants its products to the original purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to active devices that have given normal service, to sealed assemblies which have been opened or to any item which has been repaired or altered without our authorization.

We will repair, or at our option, replace any of our products which are found to be defective under the terms of this warranty.

There will be no charge for parts, labor, or forward and return normal ground transportation during the first three months of this warranty.*

There will be no charge for parts, labor, or return normal ground transportation during the fourth through twelfth month of this warranty.*

Except for such repair or replacement, we will not be liable for any incidental damages or for any consequential damages, as those terms are defined in Section 2-715 of the Uniform Commercial Code, in connection with products covered by this warranty.

*For *overseas shipments*, there will be no charge for Air Freight during these specified time periods.

BOONTON

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